SGIIIII

Air brake manual

safety

Air brake manual

Acknowledgments

Motor Vehicle Branch of the
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Saskatchewan Highways and Transportation

Bendix Heavy Vehicle Systems Inc.

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Brakes and braking

Heat – energy – traction – friction

To move a vehicle, an internal combustion engine must convert its **heat energy** to **mechanical energy**. This **mechanical energy** goes from the engine to the driving wheel tires by means of a system of connecting rods, shafts and gears. The final factor that moves a vehicle is the amount of **traction** its tires have on the road surface. **Traction** is the ability of a tire to grip the road surface on which it rolls. The vehicle's acceleration rate depends on the power the engine develops and the amount of **traction** the tires have on the road surface.

Friction is the force which resists movement between two surfaces in contact with each other. To stop a vehicle, brake shoe linings are forced against the machined surfaces of the brake drums, creating **friction**. This **friction** produces **heat**.

The engine converts the **energy** of **heat** into the **energy** of **motion** – the brakes must convert this energy of motion back into the **energy** of **heat**. **Friction** between brake drums and linings generates **heat**, while reducing the mechanical energy of the revolving brake drums and wheels. The heat produced is absorbed by the metal brake drums, which dissipate heat by passing it off into the atmosphere. The amount of heat the brake drums can absorb depends on the metal thickness of which they are made. When enough **friction** is created between brake linings and drums, the wheels stop turning. The final factor that stops a vehicle is not the brakes, but the **traction** between tires and road surface.

If a 200 horsepower engine accelerates a vehicle to 100 km/h in one minute, imagine the power needed to stop this same vehicle. Not only that, the vehicle might have to be stopped in an emergency, in as little as six seconds (just 1/10 of the time it took to reach 100 km/h).

To stop a vehicle in 1/10 the time it takes to accelerate requires stopping power of 10 times the acceleration power – equivalent to 2,000 horsepower. If the vehicle had six wheels, each wheel would have to provide 1/6 of the braking power. If one or two wheels had brakes that were not properly adjusted, the other wheels would have to do more than their share of the braking, and that might be more than their brakes were constructed to stand. Excessive use of the brakes would then result in a build-up of heat greater than the brake drums could absorb and dissipate. Too much heat would result in brake damage and possible failure.

Most brake linings operate best around 250°C and should not exceed 425°C (Fig. 1). It's important to understand that the power needed to stop generates heat which could ruin the brakes.

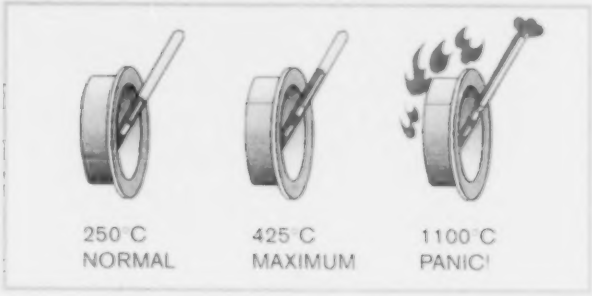


Figure 1. Brake lining temperature

Speed – weight – distance

The distance required to stop a vehicle depends on its speed and weight in addition to the factors of energy, heat and friction. The brake power required to stop a vehicle varies directly with its weight and the "square" of its speed. For example, if weight is doubled, stopping power must be doubled to stop in the same distance. If speed is doubled, stopping power must be increased four times to stop in the same distance. When weight and speed are both doubled, stopping power must be increased eight times to stop in the same distance.

Example: A vehicle carrying a load of 14,000 kg down a grade at 16 km/h is brought to a stop in a distance of 30 metres by normal brake application. If the same vehicle carried 28,000 kg down the same grade at 32 km/h, it would require eight times the braking power to stop the vehicle in 30 metres. This would be more braking power than the brakes could provide. No vehicle has enough braking power when it exceeds its limitations.

How power is obtained

A. Mechanically

Braking systems use devices to gain a mechanical advantage. The most common device for this purpose is leverage (Fig. 2).

A lever is placed on a pivot called the fulcrum. If the distance from A to C is four metres, and from C to B one metre, the

Figure 2. Simple lever.

ratio is four to one (4:1). Power is multiplied by the leverage principle. If a 100 kg downward force is applied at point A, then upward force at point B is 400 kg. This is the result of the mechanical advantage of leverage.

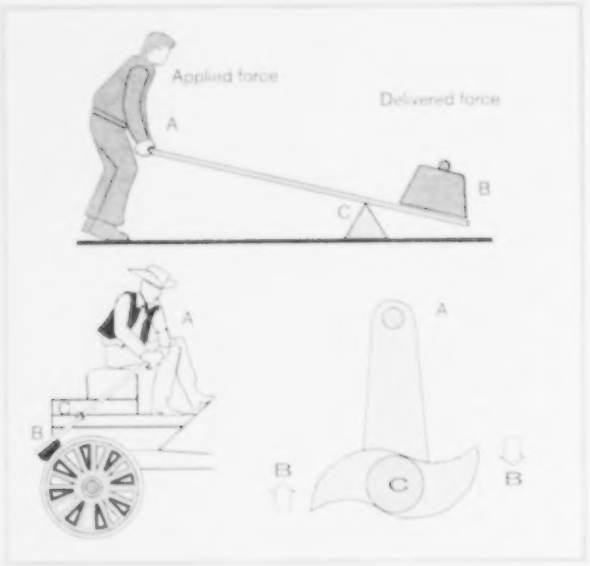


Figure 3. Various levers. Compare points A, C, B to the previous lever diagram (Fig. 2).

B. Use of air

Force can also be multiplied by the use of air to gain a further mechanical advantage. Everyone has felt the power of air on a windy day. Air can be compressed into a much smaller space than it normally occupies. For instance, air is compressed in tires to support the weight of a vehicle. The smaller the space into which air is squeezed, the greater the air's resistance to being squeezed. This resistance creates pressure, which is used to gain mechanical advantage.

If a constant supply of compressed air is directed through a pipe that is one-inch square, and if a one-square-inch plug was placed in the pipe, the compressed air would push against the plug. Holding a scale against the plug would register how many pounds of force were being exerted by the air against the plug.

If the scale registered 10 pounds, for example, then it could be said the force was 10 pounds on the one-square-inch surface of the plug (Fig. 4). This would be 10 pounds per square inch (psi).

The more the air in the supply tank has been compressed, the greater the force that would be exerted on the face of the plug.

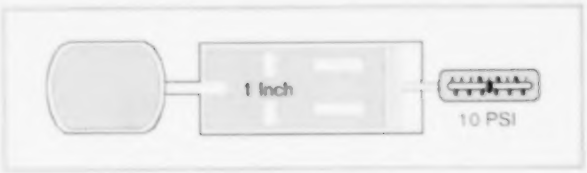


Figure 4. Pounds per square inch (psi).

C. Leverage and air pressure

In actual operation, pipes are round and plugs are diaphragms of flexible material acting against push rods. If compressed air of 120 psi acts on a diaphragm of 30 square inches (Fig. 5), 3,600 lbs. of force is produced (120 x 30). Apply this force to a push rod to move a six-inch slack adjuster operating a cam, and the total force equals 21,600 inch pounds torque (3,600 x 6), or 1,800 foot pounds torque (21,600 ÷ 12). It requires between 80 and 100 foot pounds of torque to tighten the wheel on a car. This comparison illustrates the power obtained from using mechanical leverage and air pressure combined.

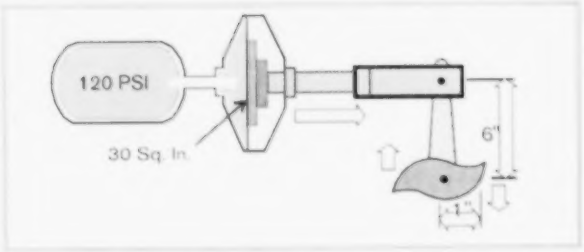


Figure 5. Air pressure combined with leverage.

Stopping distance

In addition to the factors mentioned on page 3, a driver must understand what is meant by the term "stopping distance." Stopping distance consists of three factors:

Driver's reaction time + Brake lag + Braking distance.

Reaction time:
The time it takes from the moment a hazard is recognized to the time the brake is applied, approximately 3/4 of a second (reaction time is often called "thinking time").

Brake lag:
The time air takes to travel through a properly maintained air brake system, about 4/10 of a second.

Braking distance:
The actual distance a vehicle travels after the brake is applied until the vehicle stops. This distance depends on the ability of the lining to produce friction, the brake drums to dissipate heat and the tires to grip the road.

Professional drivers never take brakes for granted. The braking system must be tested and adjustment checked before placing a vehicle into service. Professionals understand the braking system, realize its capabilities and limitations, and learn to use it to their advantage.

Heavy vehicles require powerful braking systems that are obtained by use of mechanical leverage and air pressure. Brakes must be used keeping in mind the heat generated by friction. If heat becomes too great, braking effectiveness will be lost. The heavier the load and the faster the speed, the greater the power needed to stop.

Stopping distance is also affected by the driver's reaction time, brake lag and braking distance (Fig. 6). The professional driver is well aware that the vehicle, even with properly adjusted brakes, will not stop as quickly as a passenger vehicle.

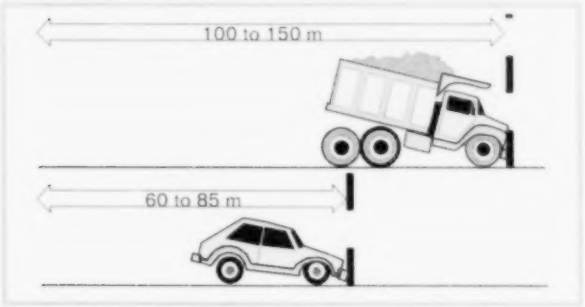


Figure 6. Stopping distance.

Section summary

1. What is the final factor that will determine if the vehicle will move?
2. What is the final factor that will determine if the vehicle will stop?
3. How is heat generated by the brakes dissipated?
4. If one set of brake shoes is poorly adjusted, what effect could it have on the remaining set of brake shoes in the system?
5. What is meant by the term **friction**?
6. If the weight of the vehicle is doubled, how many times must the stopping power be increased?
7. If vehicle weight and speed are both doubled, how many times must the stopping power be increased to be able to stop in the same distance?
8. If vehicle speed is doubled, how many times must stopping power be increased to be able to stop in the same distance?
9. What is compressed air?
10. What does the abbreviation **psi** stand for?
11. If 40 psi is exerted against a diaphragm of 30 square inches, what is the total pounds of force that could be exerted?
12. What is meant by the following terms: **reaction time**, **brake lag**, **braking distance** and **stopping distance**?

Basic system components

The five main components of an "elementary" air brake system and their purposes are:

Compressor:
to build up and maintain air pressure

Reservoirs:
to store the compressed air

Foot valve:
to draw compressed air from reservoirs when it is needed for braking

Brake chambers:
to transfer the force of compressed air to mechanical linkages

Brake shoes and drums:
to create the friction needed to stop the vehicle

Compressor

The function of the air compressor (Fig. 7) is to build up and maintain air pressure required to operate air brakes and air-powered accessories.

Air compressors are either gear driven or belt driven. Although most compressors use the truck's lubrication and cooling systems, some are self-lubricated and some are air cooled. Self-lubricated compressors must have their oil checked and changed at regular intervals.

The compressor's intake system draws air from either its own air filter or from the engine's intake system.

Compressors that have their own filtration system must be serviced on a regular basis.

All compressors run continuously while the engine is running, but air compression is controlled and limited by a **governor** which "loads" or "unloads" the compressor. In the loaded stage, air is pumped into reservoirs. In the unloaded stage (with two cylinder compressors), the compressor pumps air back and forth between the two cylinders without supplying the reservoirs.

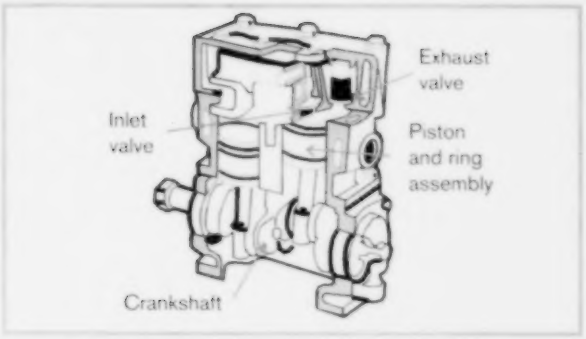


Figure 7. Air compressor.

The governor must take the compressor out of its pumping stage (unload/cut-out) when system air pressure reaches 115-135 psi (793-931 kPa), and also put it back into the pumping stage at a minimum of 80 psi (552 kPa).

Reservoirs

Reservoirs are pressure-rated tanks, which hold a supply of compressed air until required for braking or operating auxiliary air systems. They must store a sufficient volume of air to allow several brake applications if the engine stops or the compressor fails.

The maximum air pressure available for brake applications depends on how much air is in the reservoir. A driver is not able to make a higher pressure brake application than there is air pressure in the reservoir.

Each reservoir is equipped with a drain valve called a **draincock** (Fig. 8). Fully opening the draincock allows reservoirs to be drained of moisture and other contaminants that build up in the system. **All reservoirs must be completely drained once a day.**

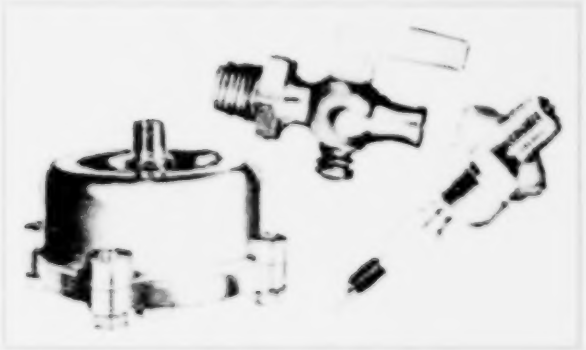


Figure 8. Typical reservoir drain valves.

Foot valve

(Application valve or treadle valve)

This foot-operated valve (Fig. 9) applies air to operate the brakes. The amount of air delivered to the brakes is regulated by the driver according to the distance the treadle or brake pedal is depressed. Releasing it exhausts air in the service brakes through its exhaust port.

Brake application valves can be divided into two types: single-circuit valves and dual-circuit valves. Trucks built before 1975 are generally equipped with single-circuit brake application valves.

These valves are made in overhead styles with a foot pedal hanging down, or a floor-mounted version with a foot "treadle."

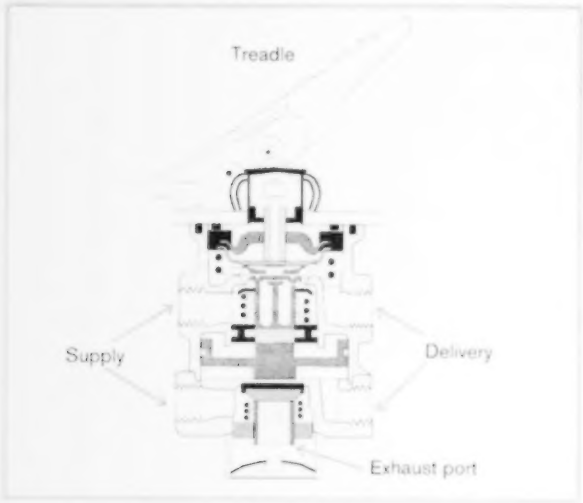


Figure 9. Dual-circuit foot valve.

Service-brake chambers

(Brake pots)

Service-brake chambers (Fig. 10) convert compressed air pressure energy into mechanical force and movement, which apply the vehicle's brakes.

When the driver applies pressure to the foot valve, air pressure enters the pressure side of the brake chamber through the inlet port and forces against the diaphragm, which moves the push rod assembly forward. When air pressure is released from the service-brake chamber, the return spring returns the diaphragm and push rod to their released positions.

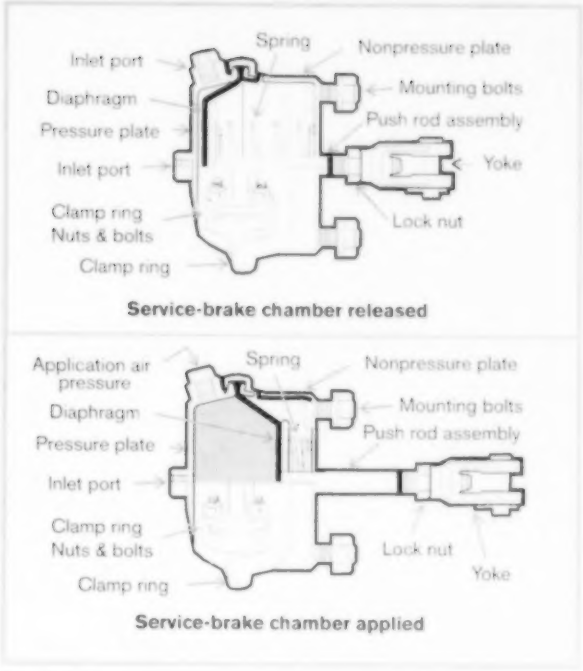


Figure 10. Clamp-ring type service brake chamber.

Brake shoes and drums

Figure 11 illustrates the common **S-cam** brake assembly used on truck and trailer axles. Front brake assemblies have the brake chamber and slack adjuster mounted on the backing plate because the steering action of the front axle would otherwise interfere.

The diagram shows the brakes in the applied position. The S-cam is rotated so the high points have acted against the **cam rollers** and forced the brake shoes against the drum.

When the brakes are released, the brake cam shaft returns the brake cam to the normal position. The cam rollers roll down into the crook of the S-cam as the brake shoe return spring pulls the shoes away from the drum.

Brake lining material is attached to the face of the shoes. Lining material is selected according to the type of service the brakes are subjected to. Linings must give consistent braking output with minimum fade at high temperatures.

Brake shoes generate heat through friction with the brake drum surface. Drum thickness determines the amount of heat that can be absorbed and dissipated to the atmosphere. Thin or distorted drums, weak return springs, improper linings, poor adjustment, or grease or dirt on the

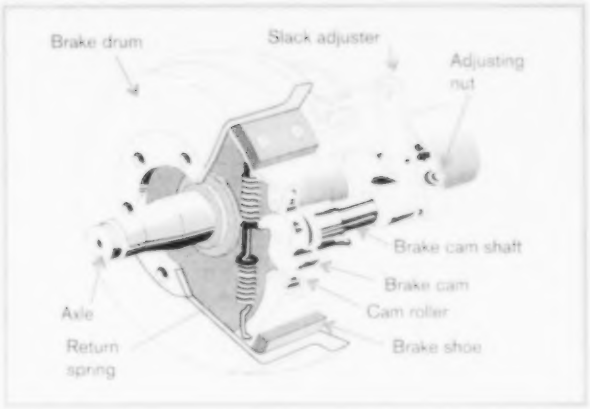


Figure 11. S-cam brake assembly.

lining, will all result in erratic, unpredictable and potentially dangerous brake performance.

Figure 12 illustrates a **wedge-actuated** brake assembly used on some air brake equipped vehicles. Air chamber push rod action forces a wedge-shaped push rod between the brake shoe rollers. This forces the brake shoe lining against the brake drum. Each wheel may be equipped with one or two chambers, depending on vehicle size and style.

These brakes may be equipped with a self-adjusting mechanism or a manual "star wheel" adjuster. The "star wheel" adjustment is made with the vehicle jacked up, to ensure that the brake linings do not drag. Manual adjustment of wedge-type brakes is usually a job for a mechanic.

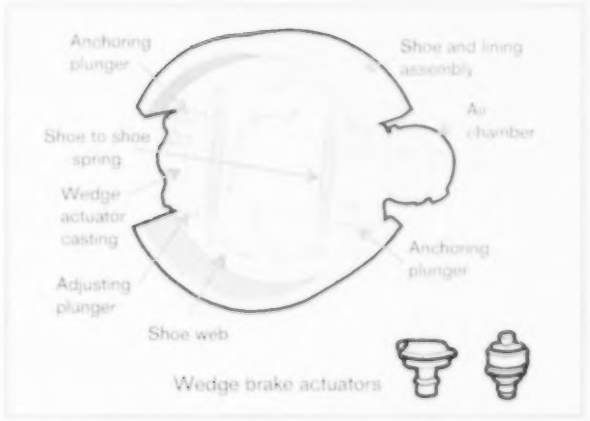


Figure 12. Wedge-actuated brake assembly.

Basic system operation

Basic air brake system

Air is pumped by the compressor to the reservoir. When air pressure reaches 115 to 135 psi (793 to 931 kPa), the governor places the compressor into its unloaded stage. At this stage the air system is fully charged (Fig. 13).

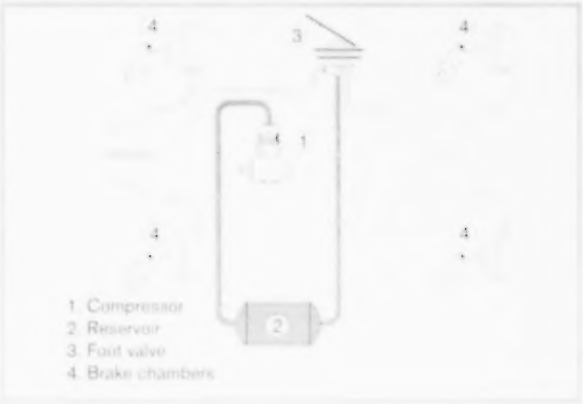


Figure 13. Basic air brake system.

When the brakes are applied, air is delivered through the foot valve to the service-brake chambers (Fig. 14). Air pushes against each service-brake diaphragm causing the

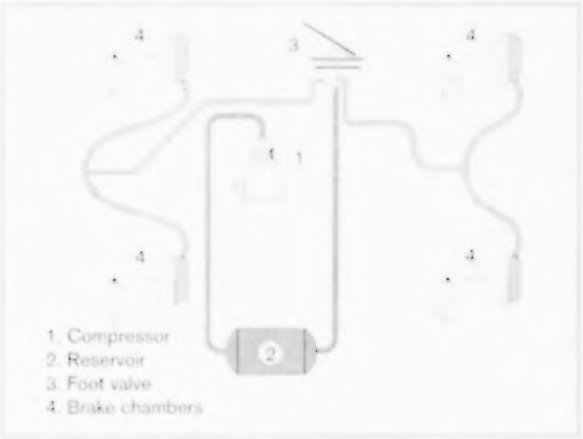


Figure 14. Brake application.

push rod to move the slack adjuster. The slack adjuster rotates the brake cam, which forces the shoes against the brake drum.

When the driver releases the foot valve, air in the brake chambers is exhausted through the foot valve, which releases the brakes.

When reservoir air pressure drops, the governor puts the compressor back into the pumping stage to keep adequate air pressure available for future brake applications.

Additions to the basic system

Several additions (Fig. 15) can be made to the basic system to improve it:

- service reservoir
- air pressure gauge
- low warning switch
- relay valve
- front-brake limiting valve or automatic front brake ratio valve
- one-way check valve
- stop light switch

Reservoir

Figure 15 shows that an additional air reservoir has been added. Since the first reservoir is closest to the compressor it is now called the **supply** reservoir. It is sometimes called the wet reservoir because most of the water and oil from the compressor gathers here.

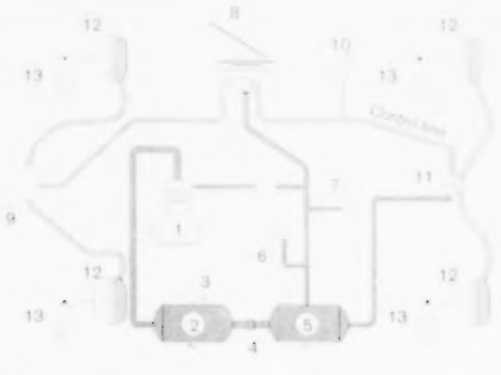


Figure 15. Basic system plus additions.

The second reservoir is called the **service reservoir**. Air is drawn from this reservoir to operate the brakes.

Safety valve

The supply reservoir is protected from being over-pressurized and bursting by a **safety valve** (Fig. 16). This valve is pre-set (usually at 150 psi [1,034 kPa]) and will "blow off" excess pressure. Once pressure is lowered, the safety valve will re-seal until an over-pressurized condition exists again. If a safety valve "blows off" excess pressure, this indicates a problem with the governor. The problem should be dealt with immediately by a mechanic.

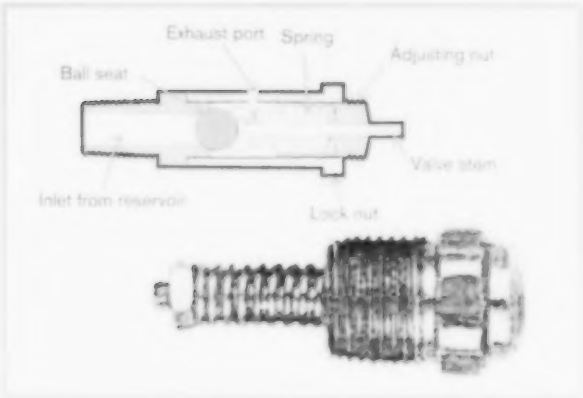


Figure 16. Safety valves.

One-way check valve

In case the air compressor fails or a leak develops in the supply reservoir, a **one-way check valve** (Fig. 17) is installed between the reservoirs to keep air from bleeding back. The valve is spring loaded. Pressure at the inlet side overcomes spring pressure and lifts a check ball or disc off its seat. Air passes through the valve to the outlet. When pressure at the outlet becomes greater than at the inlet, together with spring pressure, the check device seats, preventing air from flowing back through the valve.

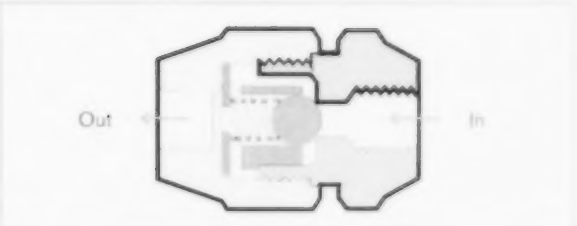


Figure 17. One-way check valve.

Air pressure gauge

An air pressure gauge (Fig. 18) is installed in the dash (plumbed in after the service reservoir) so the driver will know the amount of air pressure available for braking.

Figure 18. Air pressure gauge.

Air governor

The **governor** (Fig. 19), which is usually compressor mounted, operates in conjunction with the compressor unloading mechanism and maintains reservoir air pressure between a predetermined maximum and minimum pressure.

- cut-out pressure 115 to 135 psi (793 to 931 kPa)
- cut-in pressure 80 psi (552 kPa) minimum

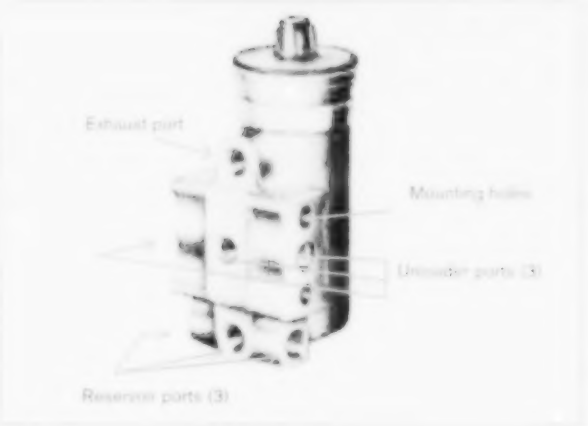


Figure 19. Air governor.

Relay valve

On long wheelbase trucks and tractors and on trailers, the distance from the brake chambers to the foot valve is too far to cause immediate application of the brake when the foot valve is depressed. This is called **brake lag**. To correct this situation, a **relay valve** (Fig. 20) is installed near the rear brake chambers. A large diameter pipe is connected between the service reservoir and relay valve. The air line from the foot valve to the relay valve now becomes a **control line** that signals to the relay valve the amount of air to be drawn from the service reservoir.

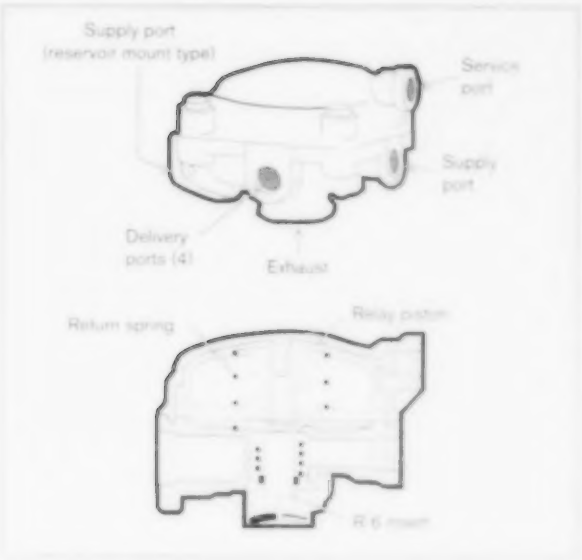


Figure 20. Relay valve.

Low warning switch

A **low warning switch** (Fig. 21) is installed on or after the supply reservoir to alert the driver when air pressure drops below a safe level (about 55 psi [379 kPa]). The switch activates either (or a combination of) a **buzzer**, **warning light** or a **wig-wag** (a "flag" that drops into the driver's view). If the low warning system activates, the driver must stop and determine the cause.

Figure 21. Low air warning switch.

Stop light switch

The stop light switch (Fig. 22) is an air-signaled electrical switch which is turned on any time a brake application is made. The switch is usually connected to a double check valve and can be plumbed anywhere in the application side of the circuit. In a tractor system it is usually plumbed into the double check valve that is matched with the tractor protection valve.

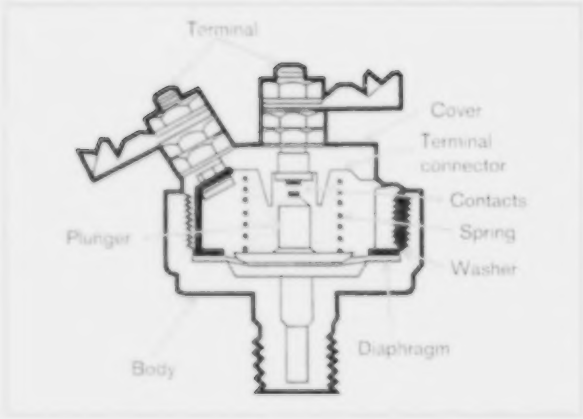


Figure 22. Stop light switch.

Quick-release valve

The function of a quick-release valve (Fig. 23) is to rapidly exhaust air from the controlled device. It is normally located adjacent to the controlled device, rather than requiring exhaust air to return and exhaust through the control valve. This decreases release time.

Figure 23. Quick-release valve.

Front axle ratio valve

Designed for use on dual-air system vehicles, the **ratio valve** (Fig. 24) is installed in the front axle delivery line. During normal brake applications, this valve automatically reduces application pressure to the front axle brakes. As brake application pressure increases, the percentage of reduction is decreased until about 60 psi (413 kPa) (depending on valve design) when full pilot pressure is delivered. The valve is available with several different "hold-off" pressures, which prevent the front brakes from operating until this "hold-off" pressure is exceeded.

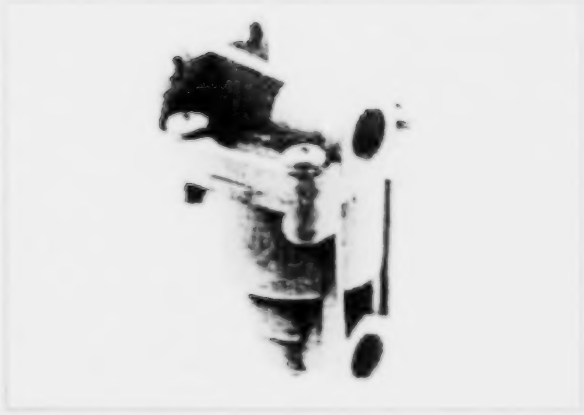


Figure 24. Front axle ratio valve.

NOTE: Older trucks may be equipped with a front wheel limiting valve controlled by a switch on the dash. When activated, this valve will reduce application pressure on the steering axle brakes by 50 per cent.

Air dryer

The air dryer (Fig. 25) is a desiccant-type in-line filtration system that removes most liquid and water vapour from compressor discharge air before it reaches the air brake reservoirs. This results in only clean, dry air being supplied to the air brake system, aiding in the prevention of air-line freeze-ups.

Air dryers utilize a replaceable desiccant material that has the ability to strip water vapour from moisture laden air. The desiccant material is regenerative, in that its absorptive properties are renewed each time the compressor is reloaded.

The air dryer end cover is equipped with an automatic drain valve, controlled by the air-system governor, and is also equipped with an integral heating element.

Air dryers do not remove **all** the moisture. **The reservoirs still need to be drained daily.**

Figure 25. Air dryer.

Section summary

1. How can the driver tell how much air pressure there is in the main reservoir?
2. What must the driver do when a low pressure warning system activates?
3. What is the purpose of a quick-release valve?
4. What is the purpose of a relay valve?
5. How is the reservoir protected from over-pressurization?
6. At what pressure will the low pressure warning device activate?
7. How is "brake lag" to rear wheels minimized?

Dual air systems

NOTE: All piping diagrams are used to illustrate basic dual circuit principles only, and are not to be interpreted as regulations for, or specifications of, dual air-brake systems.

More and more heavy-duty vehicles on the road today are using a **dual-circuit air system** (Fig. 26). The system has been developed to prevent total brake failures and give the driver more control by allowing the truck to be brought to a stop in a safe location (Fig. 27). At first glance, the dual system might seem complicated, but if you understand the basic air system described so far, and if the dual system is separated into its basic functions, it becomes quite simple.

As its name suggests, the dual system is two systems or circuits in one. There are different ways of separating the two parts of the system. On a two-axle vehicle, one circuit operates the primary reservoir and the other circuit operates the secondary reservoir.

If one circuit has a failure, the other circuit is isolated and will continue to operate.

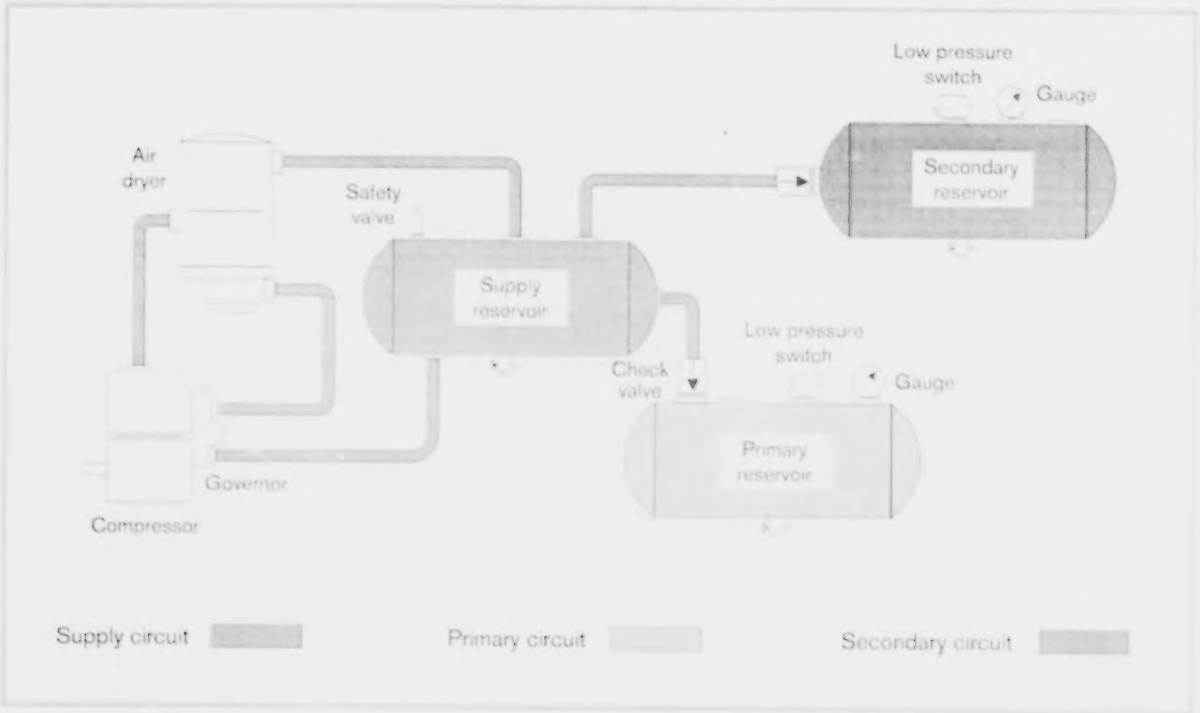


Figure 26. Simple dual circuit.

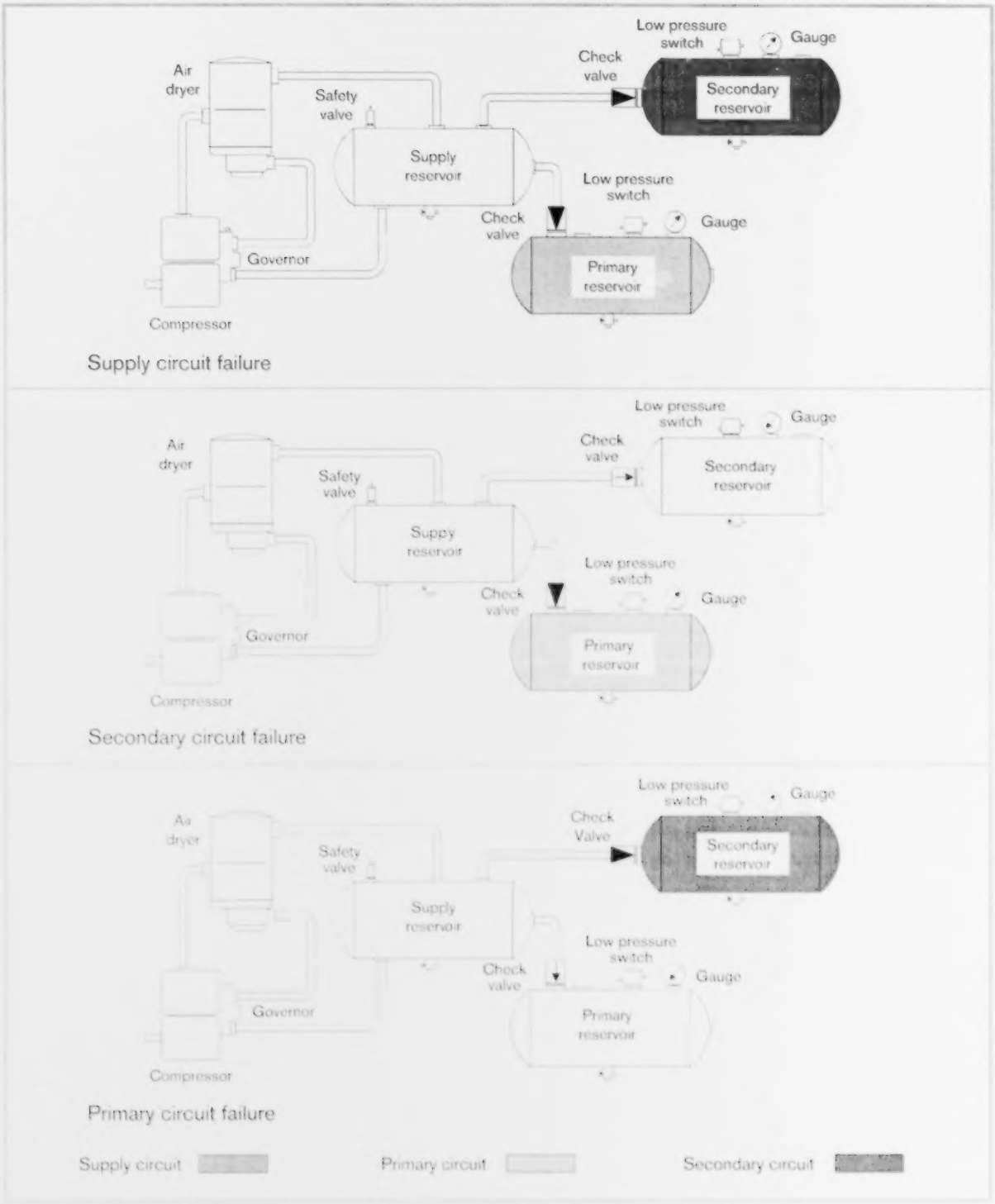


Figure 27. Simple dual-circuit failures.

Simple dual-circuit air system

In Figure 28, air is pumped by the compressor to the supply reservoir, which is protected from over-pressurization by a safety valve. Pressurized air moves from the supply reservoir to the primary reservoir (green) and the secondary reservoir (red) through one-way check valves. At this point, the dual circuits start. Air from the primary reservoir is directed to the foot valve. Air is also directed from the secondary reservoir to the foot valve. The foot valve is similar to the one described earlier in the single-circuit system, but has been divided into two sections (two foot valves in one). One section of this dual foot valve controls the primary circuit and the other section controls the secondary circuit.

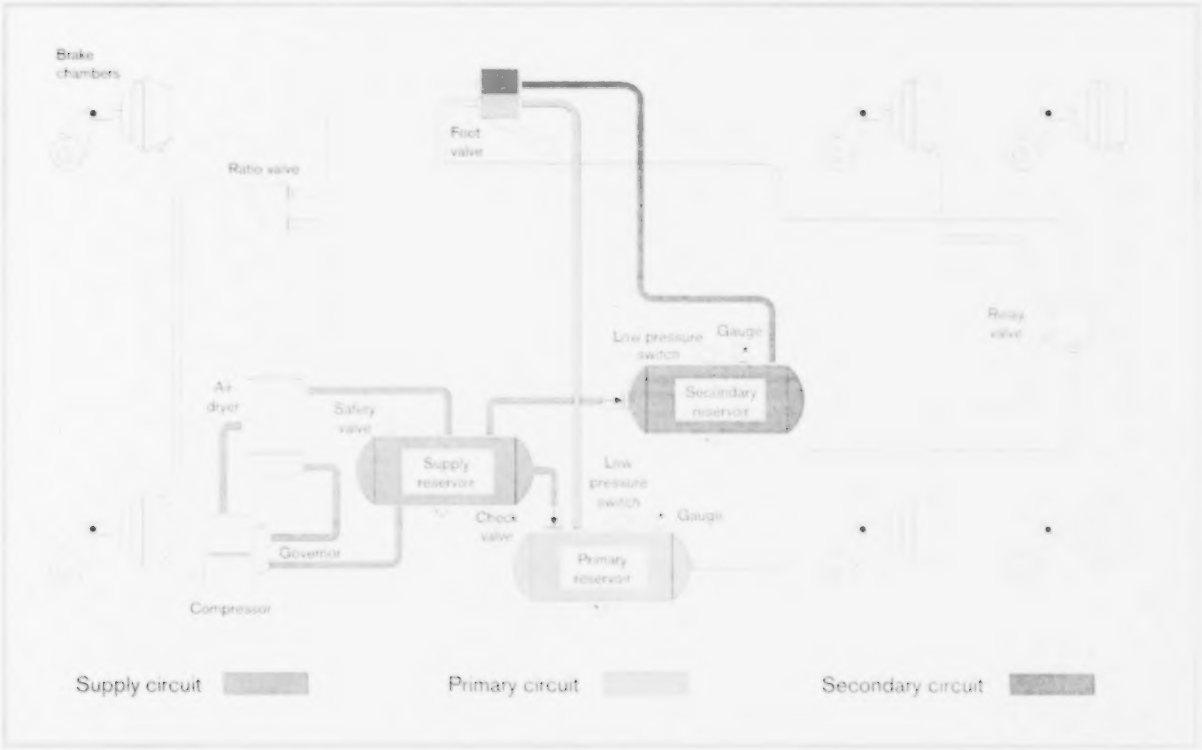


Figure 28. Simple dual circuit with brakes released.

When a brake application is made (Fig. 29), air is drawn from the primary reservoir (green) through the foot valve and is passed on to the relay valve, which delivers air from the primary reservoir to the rear brake chambers. At the same time, air is also drawn from the secondary reservoir (red), passes through the foot valve and is passed on to the front brake chambers.

If there is an air loss in either circuit, the other circuit will continue to operate independently (Fig. 30 and Fig. 31). Unless air is lost in both circuits, the vehicle will continue to have braking ability. The primary and secondary circuits are equipped with low-pressure warning devices and pressure gauges.

NOTE: Some manufacturers put one low warning switch on the supply reservoir only.

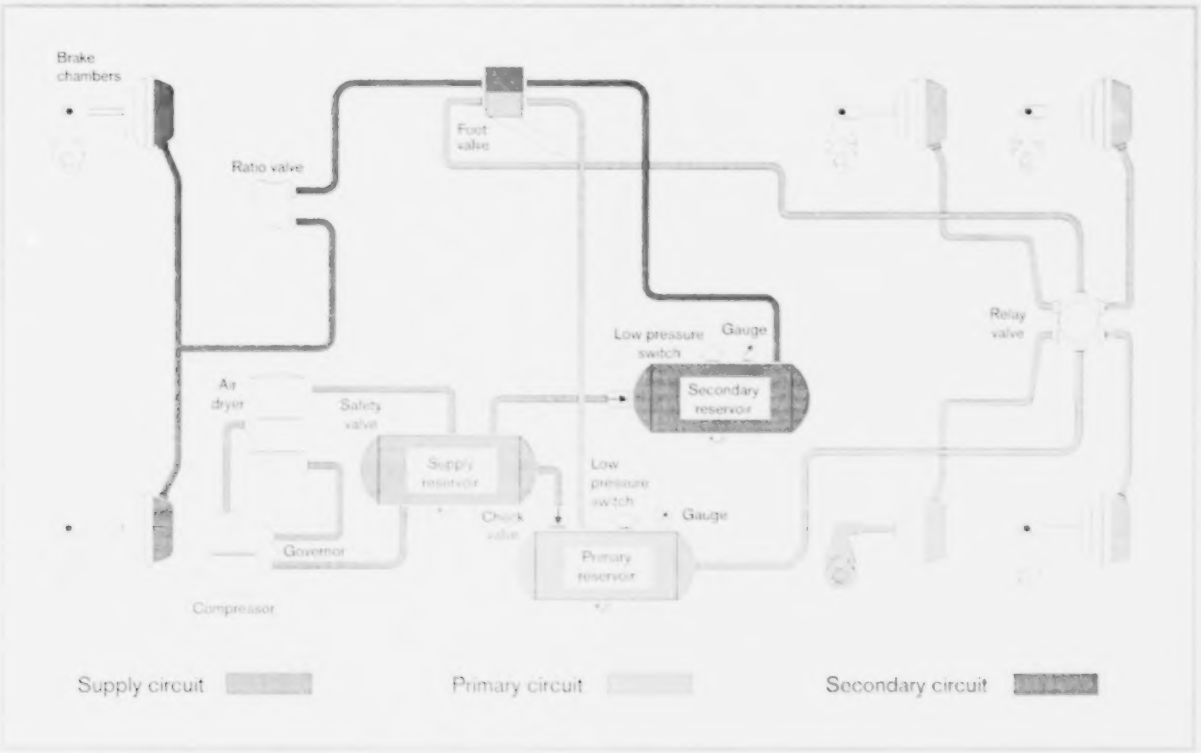


Figure 29. Simple dual circuit with brakes applied.

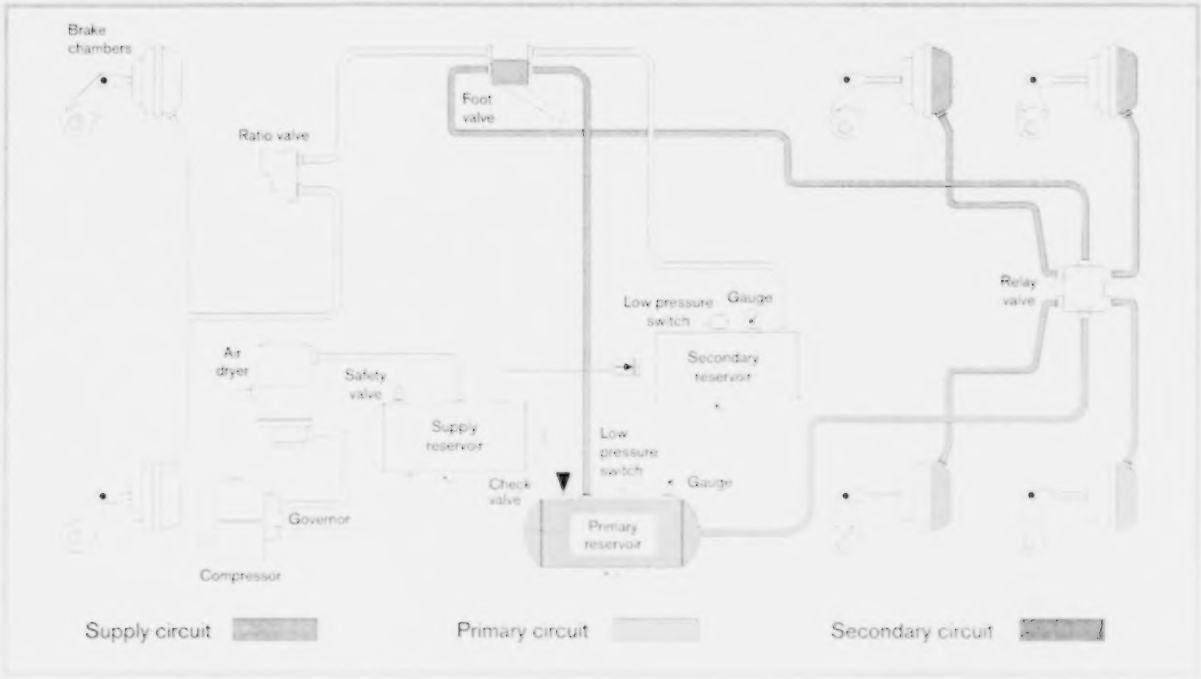


Figure 30. Secondary circuit failure with brakes applied.

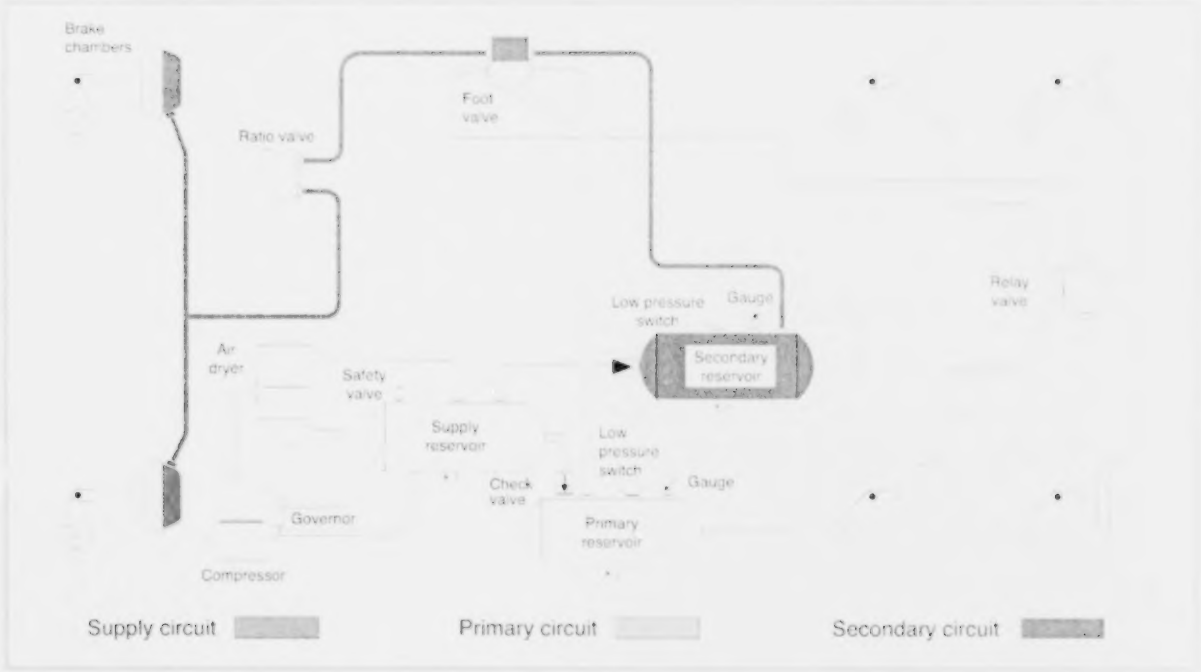


Figure 31. Primary circuit failure with brakes applied.

Spring-brake chambers

A spring-brake chamber functions as a service-brake chamber, an emergency brake in case of air-pressure loss somewhere in the system, and as a reliable spring-applied parking brake (Fig. 33). Spring brakes are installed in the same manner as service brakes and are always installed on the front tandem axle. Spring brakes are often installed on both rear axles in a tandem-axle unit. They are a reliable parking brake because they are held on by spring pressure and require no air.

Spring brakes consist of two separate air chambers. The front chamber is essentially a service-brake chamber, and is used to perform the service-brake function. The rear chamber houses a large, powerful compression spring and diaphragm and performs emergency and parking functions. It is sometimes called a "piggyback."

CAUTION: Never disassemble a spring brake. Serious injury may result. All discarded spring-brake chambers must be disassembled and disposed of by a trained professional.

The service-brake chamber applies the brake by air pressure and releases it by spring pressure (just like a single service-brake chamber).

Using an **opposite action**, the spring-brake chamber applies the spring brake by spring pressure and releases it by air pressure. In the event of air-pressure loss (an emergency or an intentional exhausting of air by the driver [while parking for example]), the power spring will push the diaphragm and push rod down and apply the brake. During normal operation, air pressure keeps the power spring compressed and allows the service brake to operate normally.

If air pressure cannot be restored and it is necessary to move the vehicle, the power spring can be compressed manually by the use of a **wind-off** bolt.

Parking-brake system

Installation of parking brakes and piping arrangements into a vehicle air brake system will vary, depending on the vehicle make.

Control valves will vary, depending on the manufacturer and type of piping arrangements.

The type of spring-loaded valve shown (Fig. 32) requires that the driver push the button to release the parking brakes. This valve cannot be left in the released position below about 20 psi (138 kPa) pressure in the main reservoir system. Any time the main reservoir pressure drops to about 20 psi (138 kPa), this valve will exhaust automatically, placing the parking brakes into full application. On some vehicles the button may not pop out until the pressure drops as low as 7 psi (48 kPa). However, always ensure the spring brakes have been fully applied. Similar types of spring-loaded valves require the driver to pull the button out to release the parking brakes.

NOTE: On some newer models the park brake button will not pop out automatically. However, the brakes will still apply.

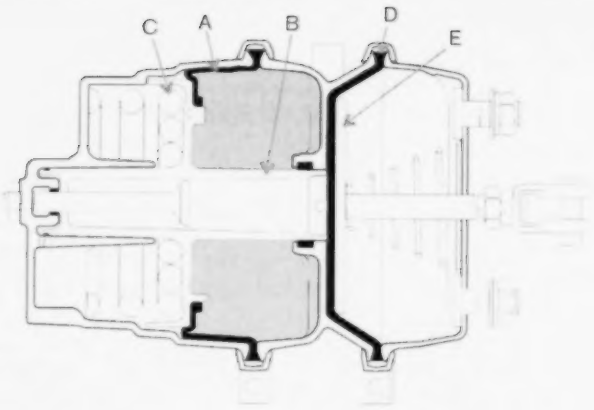
Figure 32. Park-brake control valve.

NOTE: There is a toggle control valve in use that does not have an automatic brake application feature. The park brakes will gradually apply as the air pressure is depleted, however, the control valve will not move. When air pressure is restored, the park brakes will release if the toggle valve is not manually moved to the park brake "on" position.

CAUTION: Parking brakes should be in the released position before making a service-brake application to avoid "compounding" the force exerted on brake linkages and components—which can result in damaged brake components and possibly brake failure.

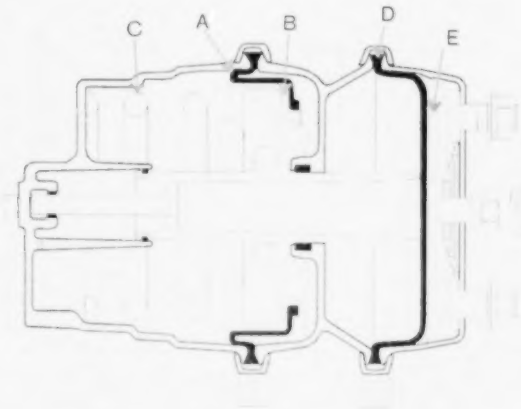
System charged – normal running condition

With air pressure of 70 psi (483 kPa) or greater acting upon the emergency diaphragm (A) and piston (B) in the spring hold-off cavity, the spring (C) is fully compressed and the piston (B) is held in the released position. This does not affect the service diaphragm (D) or service push plate and rod (E).



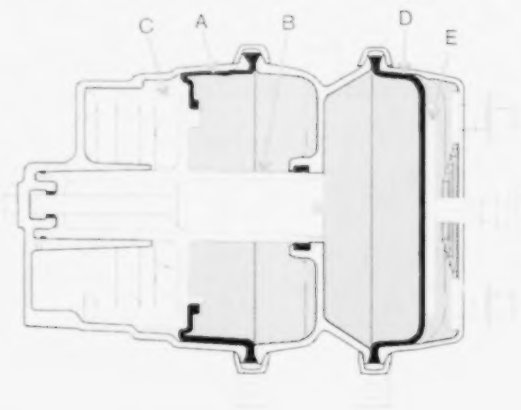
Park and emergency application

When the driver operates the park control valve, air is exhausted from the spring hold-off cavity. The spring (C) is now allowed to extend, forcing the piston (B) and the diaphragm (A) forward. The piston (B) forces the service diaphragm (D) and service push plate and rod (E) forward applying the brakes. To release the park application, the park control valve is placed in the "release" position, releasing the brakes as described under "System charged – normal running condition."



Service application

During a controlled service brake application, air pressure enters the service port and acts upon the service diaphragm (D), which forces the service push plate and rod (E) forward, applying force to the slack adjuster. The slack adjuster rotates the camshaft and applies the brakes. The emergency spring is held in the compressed position by air pressure in the spring hold-off cavity.



Spring brake hold-off pressure

Service air pressure

Atmosphere pressure

Figure 33. Spring brakes.

Simple dual-circuit system with spring parking brakes

When spring brakes are added to a dual-circuit system, the same type of dash control valve discussed previously is used (Fig. 34). Blended air is used to supply the control valve. Blended air is taken from the primary and secondary circuits through a two-way check valve.

Two-way check valve

This valve (Fig. 35) allows air to be directed to one delivery pipe from either of two sources. A two-way check valve allows the source applying the higher pressure to shift the shuttle so that the higher pressure will be directed to the delivery port.

With this piping arrangement, the vehicle can have a failure in either circuit without the spring brakes applying automatically. Unless air is lost in both circuits, the spring brakes will not apply.

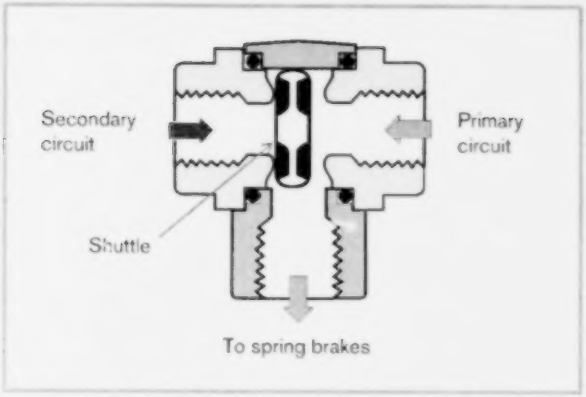


Figure 35. Two-way check valve.

In Figure 35 the primary circuit has a higher air pressure than the secondary circuit. The shuttle has blocked off the secondary port and the spring brakes are held off by primary air pressure. This also works in the opposite way.

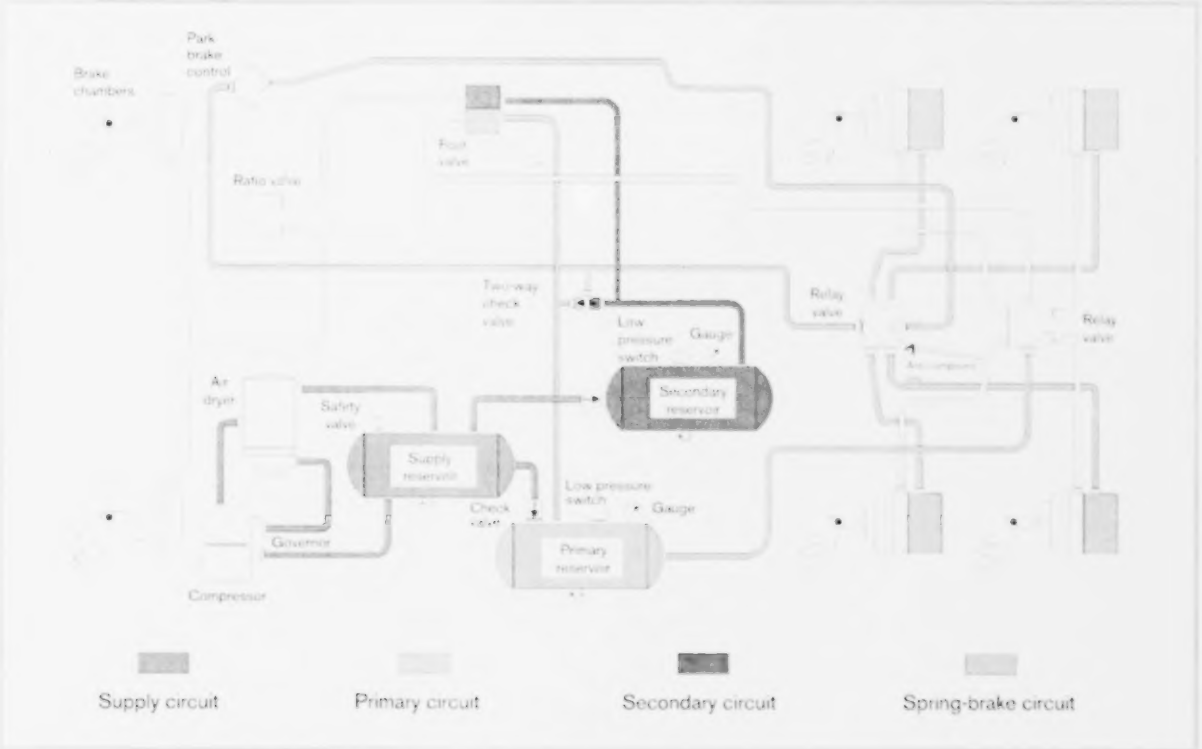


Figure 34. Dual-circuit system with spring parking brakes. Relay valve installed in spring-brake circuit to quickly apply and release spring brakes.

Spring brakes with modulator valve

Spring-type brakes in this system serve two purposes: first, as a parking brake and second, as an emergency system. If a failure occurs in the primary circuit and a brake application is made, control air from the secondary side of the foot valve is directed to a spring-brake modulator (Fig. 36). As there is no primary supply air to maintain balance in the modulator valve (due to the primary circuit failure), the modulator valve then exhausts air pressure from the spring-brake circuit. The amount of air released is equal to the amount of air applied by the foot valve. Release of air in the spring-brake circuit causes the drive axle to brake using spring-brake pressure. When the brake is released, supply air from the secondary circuit returns the spring brakes to an off position.

NOTE: An anti-compound line is sometimes installed between the delivery side of the primary circuit relay valve and the control side of the relay valve operating the spring brakes. When a brake application is made, the relay valve operating the spring brakes gets a signal from the service brake to release the spring brakes with the same amount of pressure applied to the service brakes. This prevents service-brake and spring-brake pressure from compounding on the brake linkages.

Brake applications can be repeated until all the air from the secondary circuit is lost, but as air pressure drops below 70 psi (483 kPa), the spring brakes won't return to full off position – in fact, they will start to drag. At about 20 psi (138 kPa), the spring-brake control valve on the dash exhausts the remaining air in the spring-brake circuit, and the spring brakes are fully applied. The only way the vehicle can be moved after all air is lost is to repair the damaged circuit and recharge the system, or cage the spring-brake system.

Tandem tractors manufactured without steering axle brakes will have the primary and secondary systems split between the drive axles.

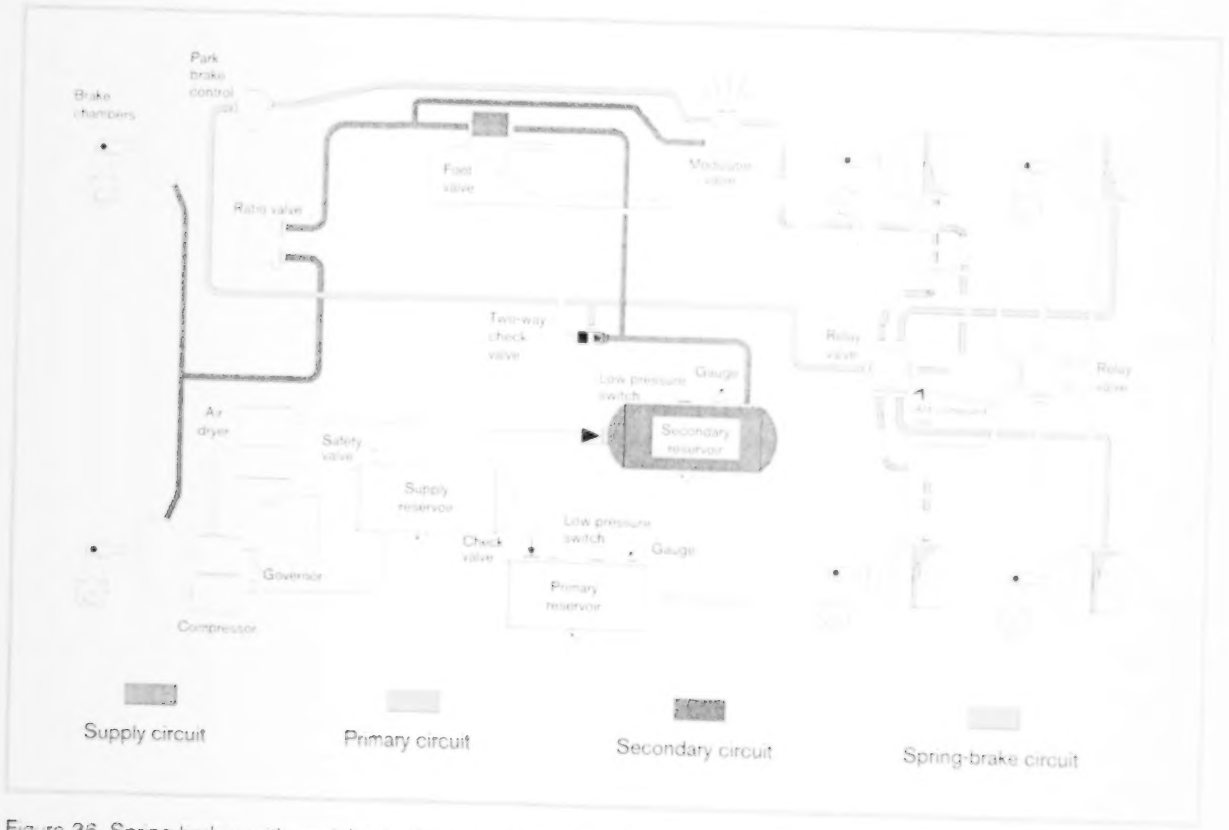


Figure 36. Spring brakes with modulator valve – primary circuit failure.

Section summary

1. What is the basic principle of the dual-circuit system?
2. What valve is used to protect the primary circuit from the secondary circuit?
3. In a simple dual-circuit system, will the vehicle continue to have braking ability if one circuit fails?
4. Is there a difference between the foot valve used in the dual-circuit system and the foot valve used in the single-circuit system?
5. What is meant by "compounding" the brakes?
6. Why are spring brakes a reliable type of parking brake?
7. How are parking brakes held in the released position?
8. What is the reason for releasing the parking brakes before making a full brake application test?
9. What is the danger of disassembling a parking-brake unit?
10. Name two functions of the spring brakes in a dual-circuit system.
11. Describe the functions of the spring-brake modulator valve.
12. What is blended air?

Tractor system/trailer towing system

To change a two- or three-axle unit into a tractor, a tractor system must be added. It consists of the following components:

Tractor protection system

The trailer-supply valve and tractor protection valve make up the tractor protection system. This system prevents air loss from the tractor when not hooked to a trailer or if a trailer breaks away. The minimum pressure at which the tractor protection system must be activated is 60 to 20 psi (413 to 138 kPa).

Trailer-supply valve

This valve is essentially another dash-mounted control valve (Fig. 37). It has two functions:

1. It controls the tractor protection valve. The tractor protection valve will not operate if the trailer-supply valve is closed.
2. It serves as a link between the tractor and the trailer parking-brake systems by supplying air to the trailer reservoirs, through the supply line.

Air is supplied to the trailer-supply valve by a double-check valve that is connected to both the primary and secondary circuits. The double-check valve only takes air from the highest pressure circuit, which prevents loss of air from a failed circuit.

Figure 37. Trailer-supply valve.

This valve (usually a red octagonal button) is mounted in the cab of the vehicle, easily accessible to the driver. The driver opens the valve by pushing or pulling the button, depending on the type used.

Opening the valve permits main reservoir pressure to flow through the valve. This pressure is piped to the tractor protection valve and the supply-line glad hand. The spring-loaded valve is held in the open position when sufficient air pressure is reached. If pressure drops to between 60 and 20 psi (413 to 138 kPa), the valve will shut automatically by spring pressure, opening the exhaust port. On some vehicles the button may not pop out until the pressure drops as low as seven psi (48 kPa). However, always ensure the spring brakes have been fully applied. The driver can close the valve manually to uncover the exhaust port.

NOTE: The trailer-supply valve has also been referred to as the emergency valve.

Manually-operated trailer-supply valves

Some vehicles are equipped with a different type of cab-mounted trailer-supply valve, which must be operated manually by the driver. It has two positions: **NORMAL** and **EMERGENCY**. The important difference is that this trailer-supply valve must be shifted to the **EMERGENCY** position manually.

Charging the trailer system:
The driver places the trailer-supply valve in the **NORMAL** position and reservoir air will be directed to the tractor protection valve and supply-line glad hand.

Trailer breakaway:
Loss of air pressure in the supply line will cause the trailer brakes to dynamite. "Dynamiting" is an emergency application that occurs when the emergency part of the valve directs trailer reservoir pressure to the trailer brakes. To prevent air loss from the tractor, the driver must shift the trailer-supply valve to the **EMERGENCY** position, otherwise the tractor air pressure will bleed down and hold at between 60 and 40 psi (413 to 275 kPa).

Tractor protection valve

A tractor protection valve (Fig. 38) is usually mounted on the cab or chassis of the tractor.

Figure 38. Tractor protection valve.

When the trailer-supply valve is open, air passes through the bottom of the tractor protection valve and charges the trailer through the supply line (also called the emergency line).

When the pressure in the supply line reaches 45 psi, the service line port of the tractor protection valve opens. This allows application air pressure to travel down the service line to the trailer when a brake application is made.

NOTE:

- The supply line always contains the same air pressure as is in the highest-pressure circuit (provided the trailer-supply valve is open).
- The service line only contains air pressure when a brake application is made and the trailer-supply valve is open.
- When you are not hooked to a trailer, the trailer-supply valve is closed and there will be no air to the tractor protection valve. Spring pressure closes the service line port. This action protects the application air pressure in the truck.
- On a trailer breakaway, air will rush out of the supply line until the trailer-supply valve automatically closes (automatic type). This prevents any more loss of air from the tractor.

Trailer hand-control valve

The hand valve (Fig. 39) is added so that the driver can apply the trailer's brakes independent of the tractor.

The hand valve is supplied from primary and secondary circuits and plumbed to a double-check valve (which is also fed from the foot valve). The double-check valve isolates either the foot valve or the hand valve, depending on which is being applied.

NOTE: Some power units are now being manufactured without a hand valve.

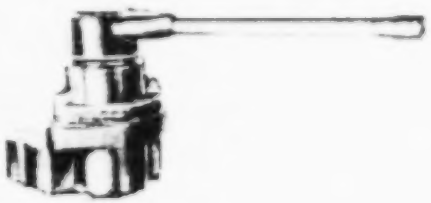


Figure 39. Trailer hand-control valve.

Independent operation of the trailer brakes has two common uses:

- To hook or unhook the trailer.
- In the event that the tractor goes into a skid, gentle brake applications using the hand valve may be of some use in trying to straighten out the unit (never apply the hand valve if the trailer goes into a skid).

CAUTION: The hand valve is **not** to be used as a parking brake.

Two-way check valve

The two-way check valve (Fig. 35) allows control of the trailer brake by use of the hand valve or foot valve. This valve will permit air to flow from the source that is supplying the higher application pressure. Two-way check valves are installed between the hand valve and the tractor protection valve, and between the foot valve and the tractor protection valve. Two-way check valves can permit a higher brake application to the trailer than the truck.

Glad hands

This term refers to the coupling device used to connect the service and supply lines of the trailer to the truck or tractor. These couplers have a snap-lock position and a rubber seal that prevents air from escaping.

Before connection is made, couplers should be clean and free of dirt and grit. When connecting the glad hands, start with the two seals together and the couplers at a 90-degree angle to each other. A quick, downward snap will jam and lock the couplers. Vehicles equipped with "dead-end" couplers should have protection plates in use whenever the vehicle is used without a trailer. This will prevent water and dirt from entering the coupler and lines.

If the unit is not equipped with dead-end couplers, the glad hand of the service line can be locked to the glad hand of the supply line to keep water and dirt from entering the unused lines. The cleaner the air supply is kept, the less chance of brake problems!

Glad hands and lines should also be secured to prevent the line from bouncing off the vehicle. This could seriously damage the couplers.

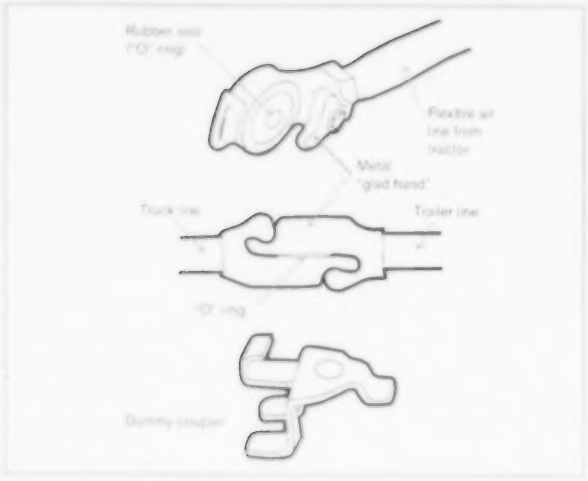


Figure 40. Glad hands.

Bobtail proportioning relay valve

The bobtail proportioning relay valve (Fig. 41) is a combination of two individual valves in a single housing. The lower portion or "body" contains a standard service-brake relay valve, which functions as a relay station to speed up brake application and release. The upper portion houses a brake proportioning valve that reduces normal service-brake application pressure when the tractor is not towing a trailer.

During bobtail operation, this valve reduces stopping distances and gives the driver greater control over the vehicle.

The driver will note that the brake pedal will have to be pushed farther to apply sufficient air to stop.

Figure 41. Bobtail proportioning relay valve.

Simple tractor-trailer system

In Figure 42, the trailer has been coupled to the tractor and the service and supply lines of the units have been coupled by using glad hands.

The trailer unit has a reservoir installed. This tank provides a volume of air near the trailer chambers for normal or emergency braking. The tank is equipped with a draincock.

A **relay emergency valve** is mounted on the trailer reservoir. This valve can also be mounted directly on the trailer frame near the brake chambers. The relay emergency valve serves three main functions in the system:

1. The relay part of the valve relays air from the trailer reservoir to the trailer-brake chambers during a brake application. This part of the valve operates like the relay valve previously discussed. It also provides a quick release of the trailer brakes.
2. The emergency part of the valve directs trailer reservoir pressure to the trailer brakes causing an emergency application sometimes referred to as "dynamiting." This action occurs automatically in the event of a ruptured or parted supply line between tractor and trailer, or loss of air from the main reservoir system. The driver may operate the cab-mounted trailer-supply valve to cause an emergency application of the trailer brakes.
3. The relay emergency valve has a one-way check valve that stops air in the reservoir from going back to the source of the supply. The driver has opened the trailer-supply valve to allow main-reservoir air pressure to be directed through the tractor protection valve to the trailer. Air pressure passes through the relay emergency valve to the trailer reservoir. Pressure builds up in the trailer reservoir to the same pressure as the main reservoirs on the tractor. This is known as "charging" the trailer system. The trailer-supply valve remains in the open position when pressure has built up to between 20 and 60 psi (138 and 413 kPa), depending on the make.
4. Drivers can check the operation of the relay emergency valve by closing the supply valve on the tractor or by disconnecting the supply line between the tractor and trailer with the supply valve in the open position.

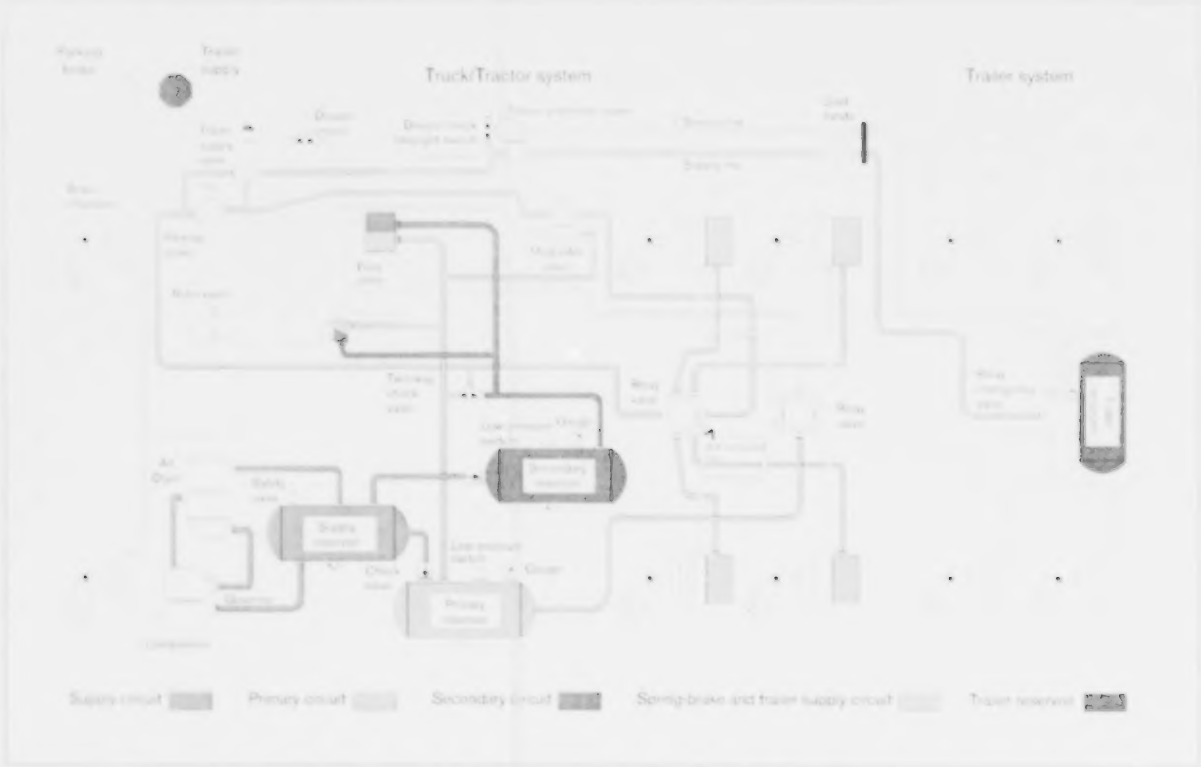


Figure 42. Typical tractor and trailer charged with air.

Brake application – foot valve

Figure 43 illustrates air flow during a brake application made with the foot valve. Application air has applied the tractor and trailer brakes together. As previously explained, the two-way check valve has shifted and application air is being directed through the tractor protection valve to the service line.

Control pressure moves through the service line to act on the relay emergency valve. Control pressure causes the relay emergency valve to direct reservoir air from the trailer tank to the trailer-brake chambers. Trailer-brake application pressure is the same as control pressure, which is the pressure of application air by the foot valve. In this system, brake lag is minimized.

Release of the foot valve stops the flow of application air. The relay portions of the valves return to their original positions, stopping the flow of air pressure. The exhaust ports of the valves exhaust air pressure from the brake chambers, releasing the brakes.

In this system, the brakes of both units can be released quickly.

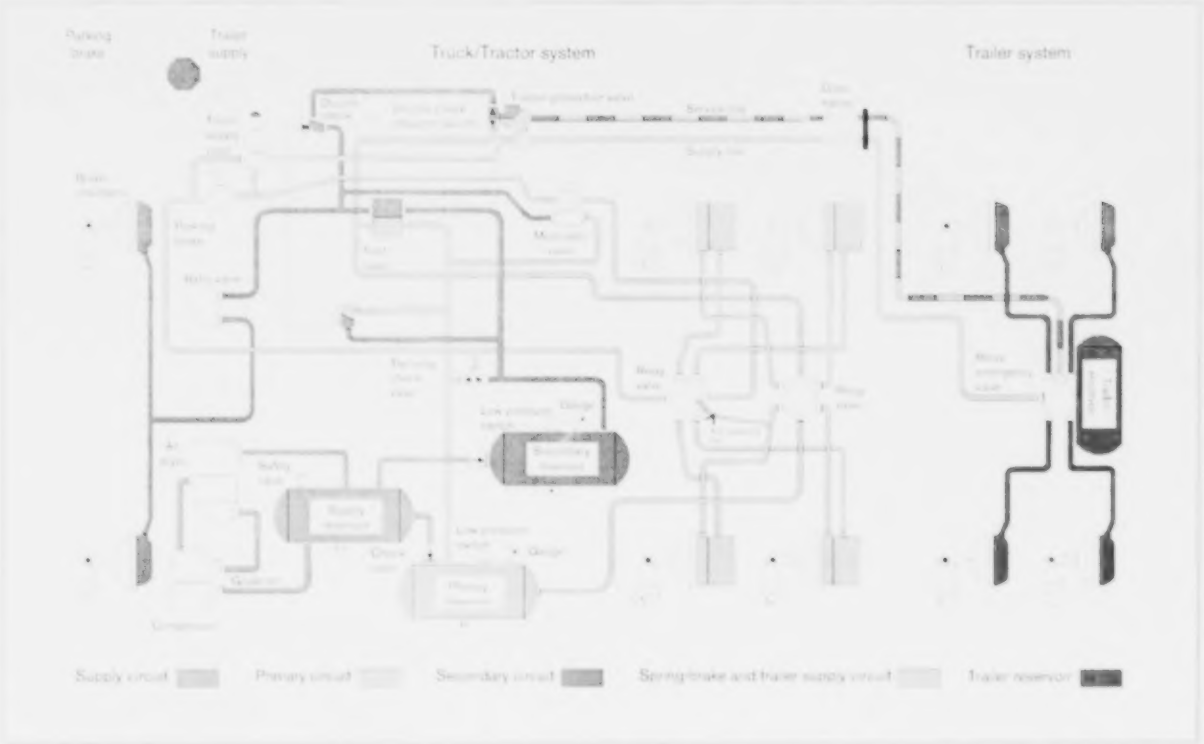


Figure 43. Tractor and trailer with foot-valve application.

Brake application – hand valve

The driver can use the hand valve to apply the trailer brakes. Air flow is illustrated in Figure 44. The tractor-protection valve and relay emergency valve are operated by application air, as explained in the foot-valve application.

Closing the hand valve releases the brakes by closing off application air. Air pressure in the chambers and lines will exhaust, also as explained in the previous foot-valve application.

CAUTION: Trailer brakes must not be used to hold a parked vehicle that is left unattended. Loss of pressure will result in loss of brakes! Always set the parking brake.

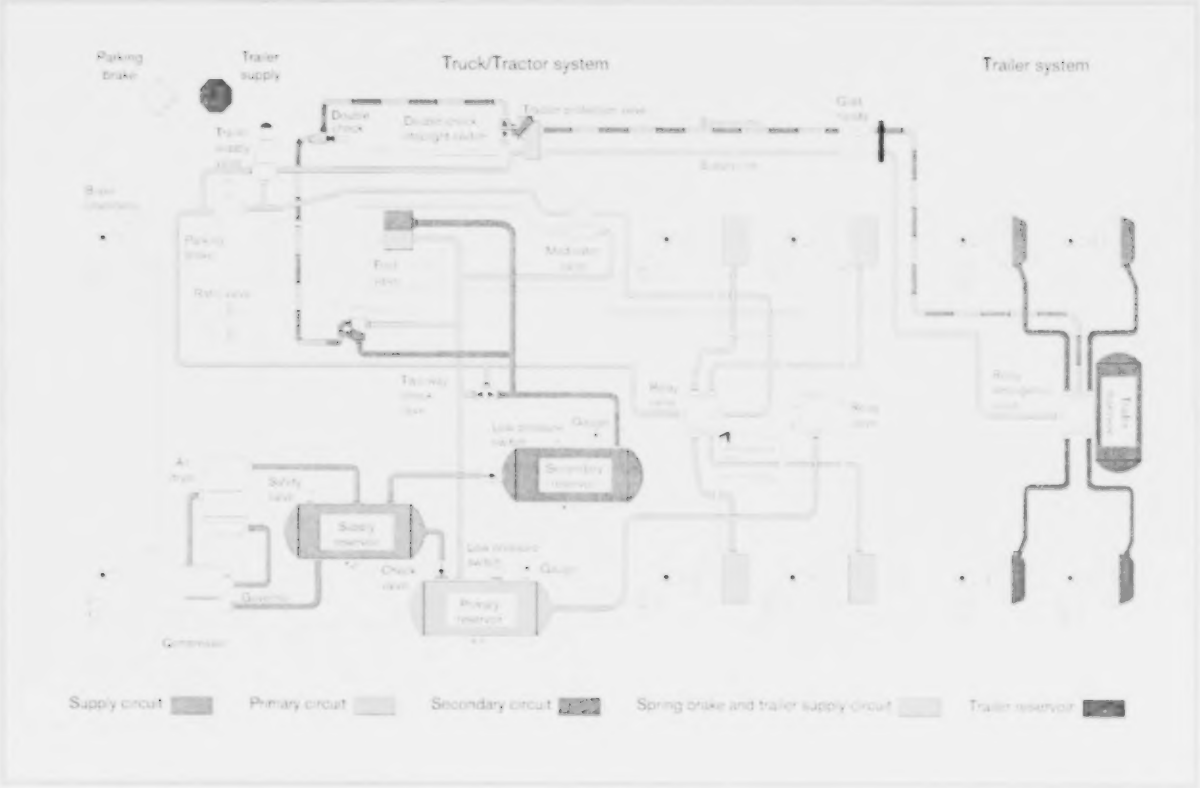


Figure 44. Tractor and trailer with trailer hand-valve application.

Emergency applications

A trailer breakaway (Fig. 45) would result in a separation of the service line and supply line. Sudden loss of air pressure in the supply line triggers the relay emergency valve, which causes the trailer reservoir to deliver its air directly to the trailer brake chambers. This places the trailer brakes into emergency application.

Loss of pressure in the supply line also causes the trailer-supply valve to automatically shift to the closed position.

The tractor brakes are operable, without air loss, because the tractor protection system has isolated the tractor.

The trailer brakes will remain applied until either the pressure in the trailer reservoir and lines are drained off or the supply line is repaired and the system is recharged.

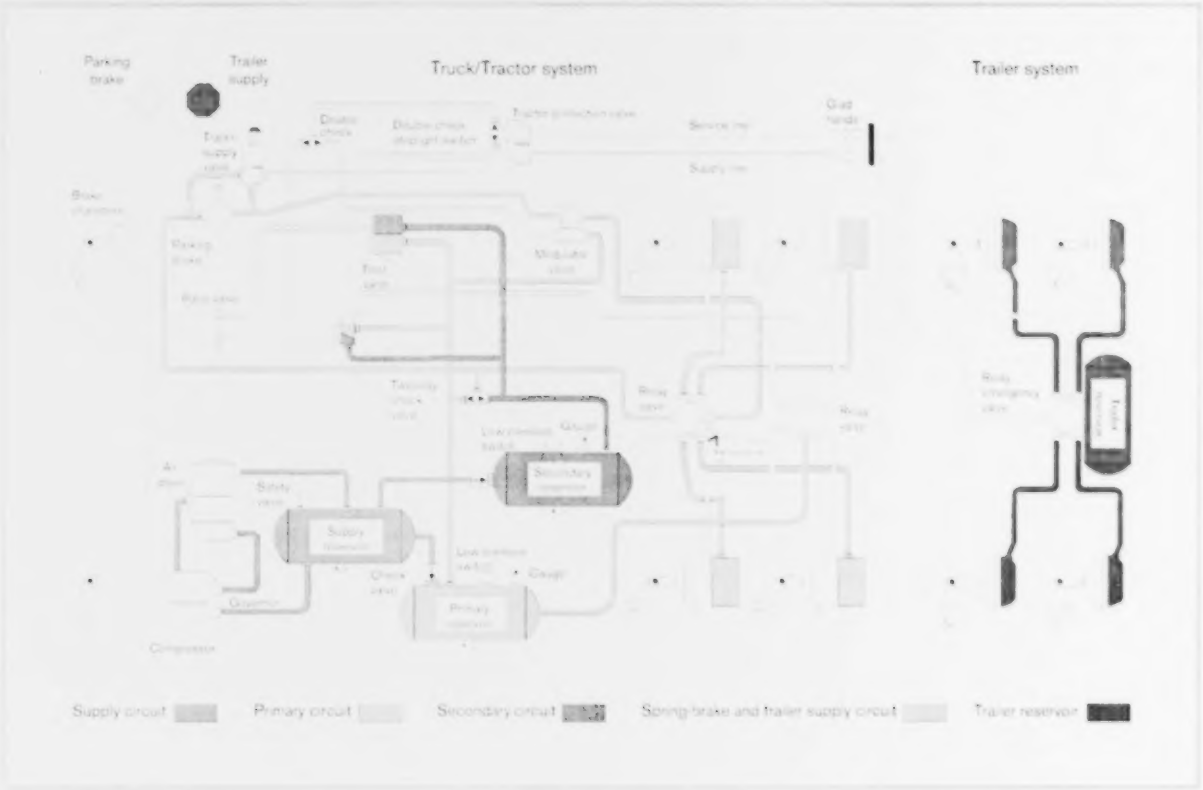


Figure 45. Tractor and trailer breakaway.

Service-line rupture

If the service line is ruptured or disconnected, no action will take place until a brake application is made.

In Figure 46, the service line has ruptured and the driver has made a brake application with the foot valve.

Application air is directed to the control line through the tractor protection valve. Rupture of the service line will result in the escape of air pressure, if the brake application is held long enough to cause enough loss of pressure in the tractor system. This pressure drop causes the tractor protection system to close off, exhausting the supply line to the trailer. This will cause the trailer brakes to go into an emergency application.

NOTE: Depending on the type of tractor protection system used, air loss from the tractor will stop immediately or it will bleed down to a minimum of 20 psi (138 kPa) and then shut off. Most newer units will shut off much higher than 20 psi.

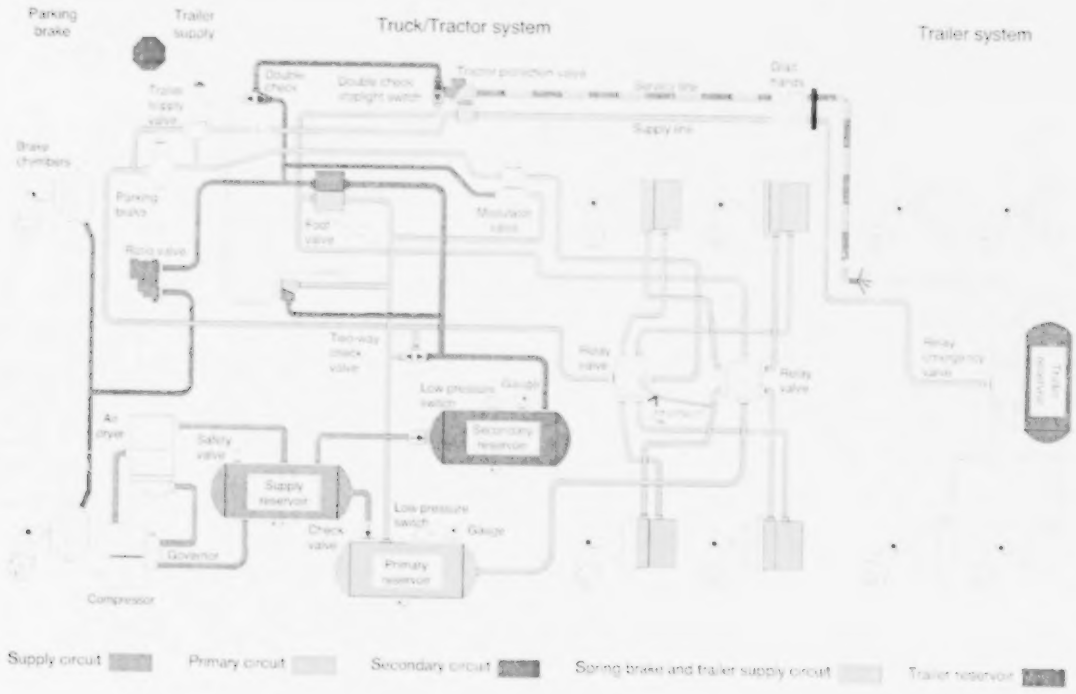


Figure 46. Tractor and trailer with service-line rupture.

Supply-line rupture

Rupture of the supply line (or an uncoupling of the supply line glad hands – Fig. 47) results in a pressure drop in the supply line between the trailer-supply valve and relay emergency valve. This triggers the emergency action of the relay emergency valve, placing the trailer brakes into emergency application. As in the previous examples, the trailer-supply valve will shift to the closed position.

Operation of the tractor brakes will not be affected if the tractor protection system is in working condition.

The relay emergency valve must be of the "no-bleed-back" type, so no air is lost from the trailer.

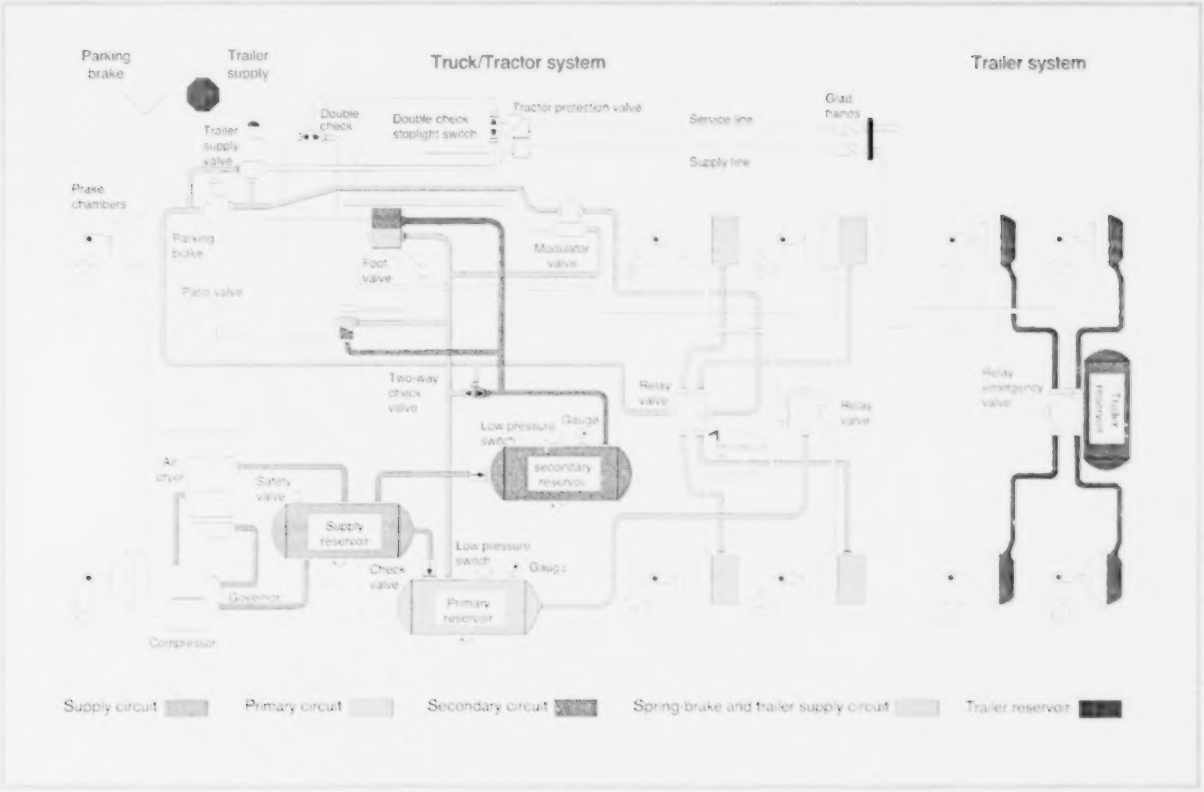


Figure 47. Tractor and trailer with supply-line rupture.

Loss of supply reservoir air

Rupture of the compressor discharge line results in loss of pressure from the supply reservoir. In Figure 48, the one-way check valves have prevented primary and secondary reservoir air from escaping back to the supply reservoir and the ruptured line.

There is sufficient reserve air pressure in the primary and secondary reservoirs for a limited number of brake applications to stop the vehicle before the parking brakes are activated.

NOTE: All manufacturers install a low air warning switch on the service reservoir. On units equipped with a dual air system, low air warning switches must be installed on both the primary and secondary reservoirs.

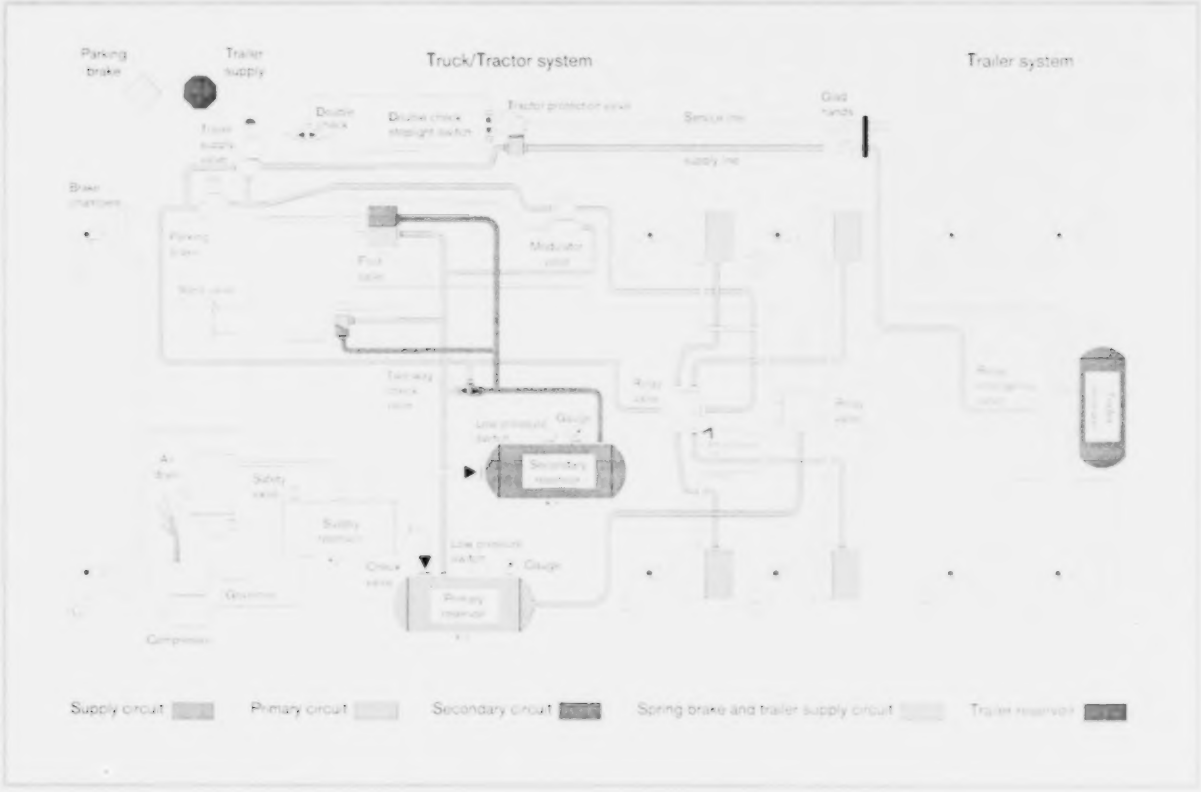


Figure 48. Tractor and trailer with loss of supply-reservoir pressure.

Spring-brake trailer system

Components of the spring-brake trailer air system (Fig. 49) are:

- front-service reservoir
- rear-service reservoir
- trailer spring-brake valve
- relay valve (same as on tractor – not an emergency relay valve as used on trailers)
- spring-brake chambers

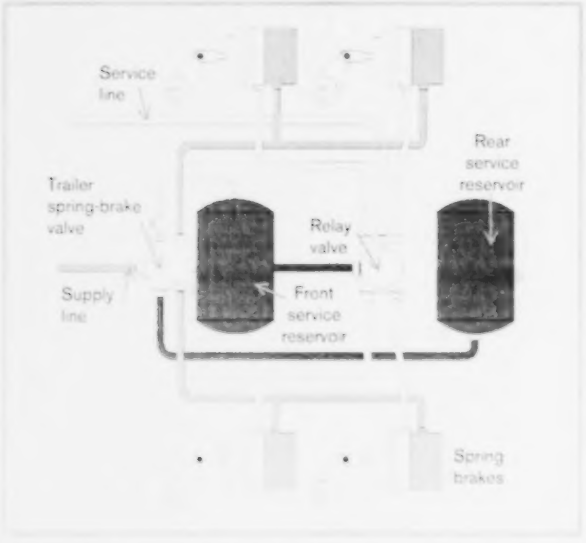


Figure 49. Trailer equipped with spring brakes.

The new component – the trailer spring-brake valve (Fig. 50) – is responsible for several important functions:

- It controls application and release of the trailer's spring brakes.
- It protects and isolates the front-service reservoir from the rear-service reservoir. This is an important feature that prevents an automatic application of the spring-brakes, even though the trailer's service reservoir is lost.
- It prevents automatic spring-brake application if the trailer's supply line has a gradual leak.
- It will automatically apply the spring brakes if supply pressure is rapidly lost (after a breakaway).
- Drivers can check the operation of the trailer spring-brake valve by closing the supply valve on the tractor or by disconnecting the supply line between the tractor and trailer with the supply valve in the open position.

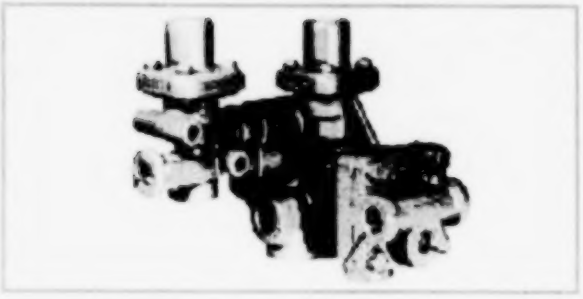


Figure 50. Trailer spring-brake valve.

Section summary

1. What is the purpose of a two-way check valve?
2. Why should the glad hands be protected when not in use?
3. How can a driver control the trailer brakes independently?
4. What are two ways of testing the emergency application of the trailer brakes?
5. Should the hand valve of a tractor trailer unit be used for parking?
6. What is the main purpose of the tractor protection valve?
7. What is the main purpose of the trailer supply valve?
8. Name three functions of the relay emergency valve.
9. Describe the function of the supply line.
10. Describe the function of the service line.
11. What will occur if the supply line ruptures?
12. What will occur if the service line ruptures?
13. What will occur if a brake application is made with a ruptured service line?
14. If the foot valve and the hand valve are operated at the same time, can the application pressure be greater to the trailer brakes than the truck brakes?

Checking and adjusting cam-type brakes

(With type-24 and type-30 chambers)

Within an inch (25 mm) of your life

The most common cause of loss of braking is poor brake adjustment. The popular type-30 air chamber has 2 1/2 inches (63.5 mm) of available stroke. A correctly-adjusted brake will have 1/2 inch (12.7 mm) to 3/4 inch (19 mm) of slack, leaving two inches (50.8 mm) of reserve chamber stroke. When slack reaches 3/4 inch (19 mm) the brakes **MUST** be adjusted. **This is the most important 3/4 inch (19 mm) of your life.**

Here's why:

- At an 80 psi (552 kPa) application, a brake chamber with 3/4 inch (19 mm) of slack will stroke 1 3/4 inches (44.5 mm) due to component stretch. This reduces reserve chamber stroke to 3/4 inch (19 mm).
- Cast iron expands when heated. On a hot brake drum this can cause the chamber to stroke a further 1/2 inch (12.7 mm), reducing reserve stroke to 1/4 inch (6.4 mm).
- At high temperature, brake lining wears rapidly. Lining wear 2.5 µm thick (the thickness of three sheets of paper) causes the chamber to stroke a further 1/4 inch (6.4 mm), resulting in the chamber "bottoming out" and a probable runaway.
- Even with cold drums, a vehicle with poorly adjusted brakes will have up to a 75 per cent longer stopping distance than normal (Table 1).

CAUTION: Under normal light braking conditions even grossly maladjusted brakes seem to respond satisfactorily. It is only under moderate to heavy braking that this **DANGEROUS** condition will become apparent.

Vehicle: 6 x 4 truck	Weight: 55,000 pounds		Speed: 60 mph	
	Average stopping distance (feet)			
	Brake lining temperature			
	150°F	200°F	300°F	400°F
Fully-adjusted brakes:	342 ft	351 ft	366 ft	393 ft
Backed-off to limit:	458 ft	519 ft	625 ft	692 ft
Increase:	34%	48%	71%	76%

Table 1. Lining temperature and stopping distance.

Checking

Pull the chamber push rod out to its limit by pulling on the slack adjuster arm or by prying with a short bar. If push rod travel is 3/4 inch (19 mm) or more, brakes **MUST** be adjusted.

Brake adjustment

Slack adjusters

Slack adjusters are mechanical links between the brake-chamber push rod and the camshaft on cam type brakes. Slack adjusters are not used with wedge-type brakes.

Slack adjusters are used to manually (Fig. 51) or automatically (Fig. 53) maintain proper brake chamber stroke and lining-to-drum clearance during normal operation.

Slack adjusters are available in a variety of arm configurations, lengths, torque ratings and spline types.

The entire slack adjuster operates as a unit, rotating with the brake camshaft as brakes are applied or released. **The most efficient braking occurs when push rod travel is held to a minimum**, therefore it is important that brake adjustments are made often.

Figure 51. Manual slack adjuster.

Manual slack adjuster check – preferred method

With service brakes in the released position, mark the push rod even with the brake chamber. Make a full brake application and mark the push rod again. Measure between the two marks to determine the length of push-rod travel (stroke).

Compare the actual stroke to the recommended maximum stroke of 1 1/2 inches (38 mm) to determine if brake adjustment is necessary.

Brake adjustment – preferred method

Raise the wheel to be adjusted off the ground so it rotates freely. Turn the slack adjustment mechanism until the wheel stops. Back off the adjustment until the wheel turns freely. This would be about one-quarter to one-half of a turn.

This method will result in the shortest possible stroke without the brakes dragging. Check push rod travel after adjustment.

Brake adjustment – alternate method

Regardless of chamber size or slack adjuster arm length, adjust the slack mechanism so there is 3/4 inch (19 mm) or less push rod travel when **manually** (by hand) extended to place the shoes in contact with the drum.

After adjustment, check for brake contact by gently striking the brake drum with a metal hammer. When the brake shoes are away from the drum, a ringing sound will be heard. A dull sound indicates brake drag and that re-adjustment is required until drag is eliminated.

Check push rod travel after adjustment.

NOTE: If the brakes can't be adjusted by either of these two methods, inspect the foundation assembly for worn or broken components.

Service tests

- Apply the brakes and check that the slack adjusters rotate freely without binding.
- Release the brakes and check that the slack adjusters return to their released position without binding.
- With brakes released, check that the angle formed by the slack adjuster arm and push rod is greater than 90 degrees (Fig. 52). All slack adjusters should be adjusted to this same angle.

NOTE: The practical test will include proper adjustment of a manual slack adjuster *and* a verbal explanation of the proper procedure for adjusting an automatic slack adjuster.

- With brakes applied (20 psi [138 kPa]), check that the new angle is no less than 90 degrees and that all slack adjusters have the same amount of travel.

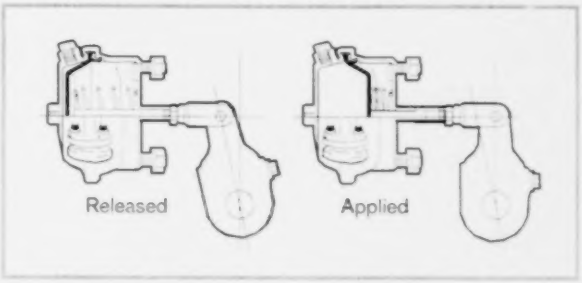


Figure 52. Slack adjuster and push rod angle.

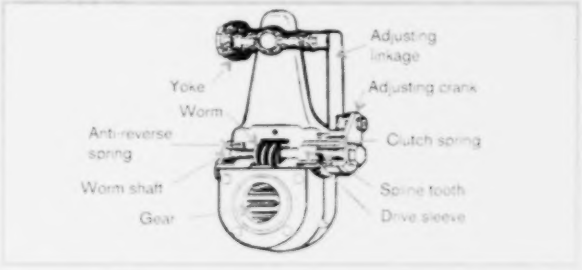


Figure 53. Automatic slack adjuster.

Automatic or self-adjusting slack adjusters

Automatic slack adjusters (Fig. 53) **adjust themselves during full brake applications** to accommodate brake lining and drum wear. However, they must be checked daily to ensure they are maintaining proper push rod travel – one inch (25.4 mm) – when manually pulled, and two inches (50.8 mm) when the brake is applied. Normally two to four brake applications of 100 psi (689 kPa) per day will keep the brakes properly adjusted. If they are badly out of adjustment it may take up to 12 brake applications to adjust them. If they are still out of adjustment, a qualified mechanic should repair them. Do not try to adjust them yourself unless you have been trained by a mechanic or trainer who is familiar with setting up and backing off this type of automatic slack adjuster.

Automatic slack adjusters **must be checked daily.**

Stroke vs. force

The amount of force available at the push rod is consistent out to two inches (50.8 mm) of stroke. After two inches (50.8 mm), push rod force drops very quickly (Fig. 54).

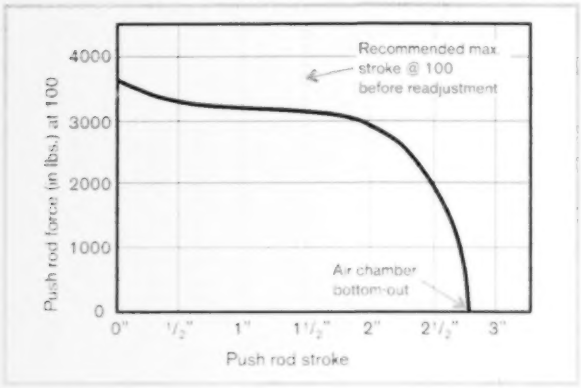


Figure 54. Push rod stroke and force.

Don't be fooled – check the slack

It is up to **YOU**, the professional driver, to ensure that your vehicle has safe, properly adjusted brakes.

Pre-trip procedure for air-single unit

Park the vehicle on level ground with the park brake set, the wheels blocked and the air tanks drained (if possible):

1. Check security and condition of compressor, belts and air lines under hood.
2. Start engine and let air pressure build up.
3. With wheels blocked, release park brakes.
4. Check brake adjustments (push rod travel) manually. Adjust if necessary.
5. Verbally explain the proper procedure for adjusting an automatic slack adjuster.
6. Governor operation (be sure spring brakes are released):
   - cut-out pressure between 115 and 135 psi (793 and 931 kPa)
   - cut-in pressure; fan brakes until compressor cuts in at a minimum of 80 psi (560 kPa)
7. At maximum pressure:
   - ensure the park brake is released
   - shut off engine
8. Make and hold full foot-brake application:
   - maximum air loss after initial application is three psi (20 kPa) in one minute
   - listen for audible air leaks
9. With ignition key on, fan brakes to lower air pressure:
   - low warning system should operate at minimum 55 psi (379 kPa)
   - truck park-brake valve should shut off at minimum 20 psi (138 kPa)
10. Start engine and rebuild air system. Time the build-up from 50 to 90 psi (345 to 620 kPa). It should be less than three minutes at a maximum of 1,200 rpm.
11. Two final tests:
    - apply park brakes and gently try to pull ahead; release park brakes
    - move slowly ahead and make foot-brake application

Steep downgrade

In some provinces, signs are posted in advance of steep or long downgrades:

These signs indicate that the driver must stop the vehicle in the pull-out area and inspect the vehicle's braking system before proceeding. Check:

1. Compressor is maintaining full reservoir pressure.
2. Push rod travel is within limitations on all chambers.
3. No audible air leaks.
4. Glad hands and lines are secure.
5. Drums, bearings and tires are not overheating.

The driver must be aware of the condition of the vehicle's braking system at all times. The driver should be able to notice any defects developing in the braking system and be aware that service or adjustments are required.

The extent of the driver's responsibility to make repairs will depend on factors such as the maintenance policy of the company and the driver's mechanical experience.

Pre-trip procedure for air combination unit

Park the vehicle on level ground with the park brake set, the wheels blocked and the air tanks drained (if possible):

1. Check security and condition of compressor, belts and airlines under hood.
2. Start engine and let air pressure build up.
3. With wheels blocked, release park brakes.
4. Check brake adjustments (push rod travel) manually. Adjust if necessary.
5. Verbally explain the proper procedure for adjusting an automatic slack adjuster.
6. Governor operation (be sure spring brakes are released):
   - cut-out pressure between 115 and 135 psi (793 and 931 kPa)
   - cut-in pressure; fan brakes until compressor cuts in at a minimum of 80 psi (560 kPa)
7. Charge trailer system and rebuild pressure. Shut off engine.
8. Break service line (no air loss should occur).
9. Break supply line:
   - trailer brakes should apply immediately
   - there should be no air loss from trailer line
   - air from truck should shut off at a minimum pressure of 20 psi (138 kPa)
10. Reconnect lines, charge trailer and rebuild pressure.
11. At maximum pressure:
    - release park brake
    - shut off engine
12. Make and hold full foot-brake application:
    - maximum air loss after initial application is four psi (28 kPa) in one minute
    - listen for audible air leaks
13. With ignition key on, fan brakes to lower air pressure:
    - low warning system should operate at minimum 55 psi (379 kPa)
    - trailer-supply valve should shut off air to trailer at a minimum of 20 psi (138 kPa)
    - truck park-brake valve should shut off at minimum 20 psi (138 kPa). On some vehicles the button may not pop out until the pressure drops as low as seven psi (48 kPa). However, always ensure the spring brakes have been fully applied.
14. Start engine and rebuild air system on truck only. Time the build-up from 50 to 90 psi (345 to 620 kPa). It should be less than three minutes at a maximum of 1,200 rpm.
15. Four final tests:
    - with trailer emergency brakes applied and truck park brakes released, try to **gently** pull ahead to test emergency application of trailer brakes
    - charge trailer, apply park brakes on the truck only and try to **gently** pull ahead
    - release park brakes, move slowly ahead and apply trailer brakes with hand valve, if equipped
    - move slowly ahead and make foot-brake application

NOTE: Repeat hand and foot-valve test on both sides of unit checking for response and, in winter, for frozen wheels.

Section summary

1. What is the maximum time permitted for the compressor to build from 50 psi to 90 psi?
2. What is the maximum pressure loss permitted after the foot brake is fully applied with the engine shut off?
3. How can trailer-brake holding power be tested?
4. Should all drivers be able to adjust, unassisted, S-cam and drum braking systems equipped with manual slack adjusters?
5. What is the final brake test that should be made before the vehicle is put into service?
6. How much push rod travel is allowed before a brake adjustment must be made?

One person alone is fully responsible to ensure that the braking system is in safe operating condition before the vehicle moves:

THE DRIVER

Air brake manual summary

1. Name the five basic components of an air brake system.

   (1) _____

   (2) _____

   (3) _____

   (4) _____

   (5) _____

2. The maximum air pressure available for a full brake application depends on?

_____

3. The most common cause of loss of braking effort on air brake-equipped vehicles is?

_____

_____

4. How often should the reservoirs be drained of moisture and sludge accumulation?

_____

5. What must an operator do when a low-pressure warning buzzer sounds?

_____

6. What is the minimum pressure at which the compressor should cut in? _____ psi

7. If the safety valve on the reservoir blows, it would indicate what?

_____

_____

8. What is the purpose of a relay valve?

_____

_____

9. How are spring brakes held in the released position?

_____

_____

10. Spring brakes are most effective as a:

_____

_____

11. The function of the slack adjuster is:

_____

12. Why should spring brakes be released before making a brake application?

_____

_____

13. Maximum reservoir pressure loss through leaks is:

_____ psi in _____ minutes for combination units

_____ psi in _____ minutes for single units

14. What factor determines how much heat can be absorbed by the brake drum?

_____

_____

15. What is the final check to be made by the operator before leaving the yard?

_____

_____

_____

Conversion charts

kiloPascals (kPa) to pounds per square inch (psi)

kPa	0	1	2	3	4	5	6	7	8	9	kPa
	psi	psi	psi	psi	psi	psi	psi	psi	psi	psi	
–	–	0.15	0.29	0.44	0.58	0.73	0.87	1.02	1.16	1.30	–
10	1.45	1.59	1.74	1.89	2.03	2.16	2.32	2.47	2.61	2.76	10
20	2.90	3.05	3.19	3.34	3.48	3.63	3.77	3.92	4.06	4.21	20
30	4.35	4.50	4.64	4.78	4.93	5.08	5.22	5.37	5.51	5.66	30
40	5.80	5.95	6.09	6.24	6.38	6.53	6.67	6.82	6.96	7.11	40
50	7.25	7.40	7.54	7.69	7.83	7.98	8.12	8.27	8.41	8.56	50
60	8.70	8.85	8.99	9.14	9.18	9.43	9.57	9.72	9.86	10.01	60
70	10.15	10.30	10.44	10.59	10.73	10.88	11.02	11.17	11.31	11.46	70
80	11.60	11.75	11.89	12.04	12.18	12.33	12.47	12.62	12.76	12.91	80
90	13.05	13.20	13.34	13.49	13.63	13.78	13.92	14.07	14.21	14.36	90
100	14.50	14.65	14.79	14.94	15.08	15.23	15.37	15.52	15.66	15.81	100

Pounds per square inch (psi) to kiloPascals (kPa)

psi	0	1	2	3	4	5	6	7	8	9	psi
	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	kPa	
–	–	6.89	13.79	20.68	27.58	34.47	41.37	48.27	55.16	62.05	–
10	68.95	75.84	82.74	89.63	98.53	103.42	110.32	117.21	124.11	131.00	10
20	137.90	144.79	151.68	158.58	165.47	172.37	179.26	186.16	193.05	199.95	20
30	206.84	213.74	220.63	227.53	234.42	241.32	248.21	255.11	262.00	268.90	30
40	275.79	282.69	289.58	296.47	303.37	310.26	317.16	324.05	330.95	337.84	40
50	344.74	351.63	358.53	365.42	372.32	379.21	386.11	393.00	399.90	406.79	50
60	412.69	420.58	427.47	434.37	441.26	448.16	455.05	461.95	468.84	475.74	60
70	482.63	489.53	496.42	503.32	510.21	517.11	524.00	530.90	537.79	544.69	70
80	551.58	558.48	565.37	572.26	579.16	586.05	592.95	599.84	606.74	613.63	80
90	620.53	627.42	634.32	641.21	648.11	655.00	661.90	668.80	675.69	682.58	90
100	689.48	696.37	703.27	710.16	717.05	723.95	730.84	737.74	744.63	751.53	100